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REACTION TIME: A BIBLIOGRAPHY WITH ABSTRACTS

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October 1969

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ABSTRACT

This bibliography is a compilation of 540 abstracted references dealing with reaction time in selected human information-processing tasks, through May, 1969.

INTRODUCTION

Every psychologist has a card file or cabinet full of reprints and preprints. Since our files contained some 200-300 references pertaining to reaction time, we decided to search the literature some more. This bibliography is the result.

We tried to limit ourselves to cognitive determinants of simple and choice reactions and to discrete reaction times measured under the rubric of human information processing. We omitted other areas because our own knowledge of the appropriate literature is limited. Areas omitted include reaction-time measures in studies involving classical and instrumental conditioning, memory, vigilance, tracking, aging, psychopharmacology, personality variables, behavioral differences between normals and subnormals, etc. To the extent that this screening process was not successful, flavor has been added. We also attempted to restrict ourselves to English-language open-literature reports, but once we allowed for a few exceptions this rule became difficult to enforce.

The bibliography is arranged alphabetically by author. The experienced investigator should appreciate this organization. The reader with little or no background in reaction time and who is primarily interested in handbook data should start with reference numbers 163, 345, 535, 536.

Omissions, other than those described above, were unintentional and accidental, and our apologies are hereby rendered.

A

1. Adams, J. A. Test of the hypothesis of psychological refractory period. Journal of Experimental Psychology, 1962, 64, 280-287.

An experiment was performed to test the hypothesis of psychological refractory period that is offered to account for the established finding that response to the second of two closely spaced stimuli shows decrement. One line of explanation argues for a central decision time, where time must be allowed for processing the first stimulus and response before the second sequence can be undertaken. A competing explanation is the expectancy hypothesis which ascribes decrement to S's past experience with the random array of interstimulus intervals that is usually used in experiments on this topic. Through practice, S comes to expect a longer delay and the decrement is because he is not optimally ready to respond.

The experiment involved a two-dimensional, bisenory discrete tracking task. The statistical structure of interstimulus time intervals was the experimental variable aimed towards discriminating between the two hypotheses by asking if decrement could be a function of the temporal organization of stimuli. The results supported the expectancy hypothesis. Reliably less decrement was found for Ss who trained on a stimulus series with a predominance of small time intervals and could learn behavior appropriate to them.

2. Adams, J. A. Motor skills. Annual Review of Psychology, 1964, 15, 181-202.

This review picks up about where the previous review of motor skills by Bilodeau & Bilodeau (22) left off. Mainly, the literature under scrutiny has been of the period 1960 to Spring 1963, although minor excursions into the pre-1960 era were sometimes made to establish a research frame of reference, or to develop a theme that was not highlighted by Bilodeau and Bilodeau. The type of study covered is that which is reasonably subsumed under basic research and general experimental psychology, even though engineering psychology regularly spews forth a flow of experiments on motor behavior in one applied context or another. Presumably these studies will be covered in an appropriate chapter at another time.

3. Adams, C. K., & Behar, I. Stimulus change properties of the RT ready signal. Psychonomic Science, 1966, 6, 389-390.

Two studies tested the generality of the Perkins-Logan hypothesis in the reaction-time experiment. Both studies used a parametric design with four ambient (intertrial) intensities of white noise ranging from 0 to 90 dB in all combinations with the same four intensities used as ready signals. The results were consistent with the Perkins-Logan interpretation of stimulus intensify effects as magnitude of change (increase and decrease) produced a highly significant effect in both studies. However, RTs were shorter when ready signals were decreases rather than increases in intensity (significant in one study).

4. Adams, J. A. Reply. Psychonomic Science, 1965, 3, 54.

See comment by Nickerson, R. S. Psychonomic Science, 1965, 3, 87-88.

5. Adams, J. A., & Chambers, R. W. Response to simultaneous stimulation of two sense modalities. Journal of Experimental Psychology, 1962, 63, 198-206.

An experiment was performed to answer the question of whether a human S could do two things at once without impairment. A bisensory discrete tracking task was used where a probabilistic series of simultaneous auditory and visual stimuli were presented, each stimulus series for response with a separate hand. An auditory and a visual control group each practiced only a unisensory version of the task where response was with one hand. All events were of 2-sec. duration and had time certainty, but the type of event occurring next in the series could be either certain or uncertain.

The results revealed a net superiority of bisensory over unisensory responding when stimulus events were certain. This was because S in the bisensory task usually made the two response movements together, and anticipation of certain events resulted in an increase in speed of the visual response time to that of the faster audio response time. But, when events were uncertain, impairment was inferred for bisensory responding because the faster audio response time was reduced in speed and synchronized with the slower visual response time.

6. Adamson, R. Comment on Murray and Kohfeld. Psychonomic Science, 1966, 4, 228-230.

Murray and Kohfeld (1965) interpret stimulus intensity dynamism in terms of the relation between pre-test AL and test signal intensities. An alternative assumption is made about the AL for one of their groups, and a reinterpretation of their findings is offered which incorporates a tension level intermediary between the aforementioned relationship and performance.

7. Aiken, L. R. Reaction time and the expectancy hypothesis. Perceptual and Motor Skills, 1964, 19, 655-661.

The measurement and meaning of the term expectancy and equivalent concepts as used in areas such as learning and vigilance are discussed briefly, and some experiments designed to measure the temporal course of expectancy are reviewed. A visual reaction time experiment is reported in which the effects of 1, 2, 3, or 4 recurrences of 2-, 3-, 4-, or 5-sec. "training" intervals on reaction time to a single "test" stimulus appearing 2, 3, 4, or 5 sec. after the last training stimulus were investigated. The results showed an insignificant effect of number of training intervals, but both the training and test interval effects and the interaction between the two were statistically significant. The general features of the curves plotted from the 16 training x test interval reaction time means illustrate that, under the conditions employed in the present experiment, mean reaction time is minimum when the training and test intervals are equal and increases as the absolute difference in duration of training and test intervals increases. Since expectancy in this investigation was operationally defined as the reciprocal of reaction time, the results obtained here are consistent with those of several previous investigations of the temporal course of expectancy.

8. Aiken, L. R., & Lichtenstein, M. Reaction times to regularly recurring visual stimuli. Perceptual and Motor Skills, 1964, 18, 713-720.

In this experiment, which was concerned with reaction times to regularly recurring visual stimuli, four experienced Ss made 21 serial responses at eight interstimulus intervals with eight replications each. The experiment was designed to provide answers to the following questions. With regularly recurring visual stimuli, (a) what is the relationship between foreperiod length and mean reaction time to light at the asymptote of the reaction time practice curve, and (b) what are the differences, for various foreperiod lengths, in the effects of practice on mean reaction time to light: The predicted answers to both questions (a) and (b) were confirmed. First, the relationship between interstimulus time interval and reaction time to regularly recurring visual stimuli is best depicted as an increasing function which reaches an asymptote at a different time interval for each S. In addition, practice results in a greater decrease in reaction time for the 1-and 2-sec. interstimulus intervals, and especially for the former, than for longer intervals; this effect is most pronounced after one experience with the given interstimulus interval.

9. Aiken, L. R., & Lichtenstein, M. Interstimulus and inter-response time variables in reaction times to regularly recurring visual stimuli. Perceptual and Motor Skills, 1964, 19, 339-342.

As an addendum to a previous study, it is demonstrated that having Ss react to either every fourth, every second, or every stimulus in a series of regularly recurring flashes of light results in three nearly identical positive linear relationships between reaction time and interstimulus time interval. This similarity of functions is interpreted as being due to covert reacting by S to the stimulus flashes to which no overt reaction is required. As a consequence of such covert responding, readiness to react becomes synchronized with the interstimulus time interval and does not vary appreciably with the inter-response time interval.

10. Aiken, L. R., & Williams, E. N. Three variables related to reaction time to compare single-digit numbers. Perceptual and Motor Skills, 1968, 27, 199-206.

A partial replication and extension of an investigation by Moyer and Landauer (1967) found that mean reaction time to the larger of two single-digit numbers (a) was longer when the larger number was on the left, (b) was an increasing linear function of the size of the larger number of the pair, and (c) showed both a decreasing linear trend and a cubic trend as a function of the difference between the larger and smaller numbers of a pair. The relationships of these findings to those of Moyer and Landauer (1967) are discussed, and some explanations for the similarities and differences are offered.

11. Alluisi, E. A. Frequencies, preferences, and choice reactions to letters. Perceptual and Motor Skills, 1963, 16, 109-110.

A multiple R of .672 (with predicted shrinkage to .640) was found to obtain in predicting the rank-ordered vocal disjunctive reaction times to different letters in the English alphabet with the best two of several frequency- and preference-based predictor variables. The two best predictors were rank order for frequency of use in English (fe), and rank order for preference of appearance (P).

12. Alluisi, E. A. Interaction of S-R compatibility and the rate of gain of information. Perceptual and Motor Skills, 1965, 20, 815-816.

Four school children of different ages and grades responded vocally at three levels of stimulus uncertainty (Hs) to visually presented Arabic numerals. S-R compatibility was greatest for the oldest child and least for the youngest. Reaction time (RT) was influenced by both Hs and S-R compatibility; the effect of Hs on RT was greatest where S-R compatibility was lowest.

13. Alluisi, E. A., & Martin, H. B. An information analysis of verbal and motor responses to symbolic and conventional arabic numerals. Journal of Applied Psychology, 1958, 42, 79-84.

This experiment was designed to compare the information-handling performance of Ss in making verbal and motor responses to two sets of Arabic numerals-one a set of conventional figures, the other a set of symbolic figures drawn from an eight-element straight-line matrix. The motor (key-pressing) responses to the different stimuli were made by a group of 24 Ss over a period of two days, and by five Ss over a longer period of 12 days. An identical number of different Ss made verbal (number-naming) responses for the same length periods.

When verbal responses were made, the conventional numerals were consistently superior in performance to the symbolic numerals. This was true whether performance was measured in terms of information handling (in bits/sec), time, or errors. No such clear superiority was evidenced for either set of numerals when motor responses were made.

It was suggested that this interaction of numeral type with response mode might be a stimulus-response compatibility effect resulting from use of the much-practiced ensemble of number-naming responses to conventional Arabic numerals. It was also hypothesized, considering the data of other investigators, that performance with straight-line and angular figures should be superior to performance with conventional numerals under difficult or threshold-like viewing situations as, for example, in visibility studies, but not necessarily superior under speeded-response conditions with stimuli above threshold.

With regard to practical applications, the numerals formed by the use of an eight-element "printing" matrix do not appear to be quite as satisfactory as standard AND-10400 numerals. They should not be used if other considerations are equal, but should their use be dictated by expediency the result should be only a small drop in information-handling performance.

14. Alluisi, E. A., & Muller, P. J. Verbal and motor responses to seven visual codes: A study in S-R compatibility. Journal of Experimental Psychology, 1958, 55, 247-254.

The information-handling performance of 10 Ss was measured with conventional Arabic numerals and six other symbolic visual codes under both motor- (key-pressing) and verbal-response conditions. The six symbolic codes included a set of straight-line symbolic Arabic numerals, three sets of ordered symbols based upon differences in the visual inclination of a line, a set of colors, and a set of ellipses of differing axis ratios. The two reeponse modes were used to lend generality to the results and to extend the study of S-R compatibility effects. Both self- and forced-paced rates of information presentation were used, with the latter being varied from 2 to 6 bits/sec in unit steps. The major results were as follows:

1. The seven codes fell into three clearly different groups under each response condition: the two numerical codes were superior to the three inclination codes, and these were all superior to the two remaining codes of color and ellipse-axis ratio.

2. Verbal-response performance with the two numerical codes was nearly perfect over the forced-paced rates used here. However, under all other forced-paced conditions, equivocation increased with increases in the rate of information presentation above the minimum of 2 bits/sec.

3. In self pacing, verbal responses with each code were made with greater accuracy than motor responses, but motor responses were made with greater speed than verbal.

4. Interactions of stimulus codes with response modes were found in both self- and forced-paced performances; these interactions were interpreted as illustrations of S-R compatibility effects.

15. Alluisi, E. A., Strain, G. S., & Thurmond, J. B. Stimulus-response compatibility and the rate of gain of information. Psychonomic Science, 1964, 1, 111-112.

Fifty-four Ss responded vocally at three levels of stimulus uncertainty to visually presented Arabic numerals. Responses were paired with stimuli in three ways to create ensembles that demonstrated high, intermediate, and low S-R compatibility effects. RT was found to be an increasing linear function of the amount of information transmitted (Ht); the degree to which RT is influenced by Ht was found to be an inverse function of the degree of S-R compatibility.

16. Andreassi, J. L. Effects of regular and irregular signal patterns upon skin conductance and reaction time. Perceptual and Motor Skills, 1966, 23, 975-978.

An experiment was conducted to study the effects of stimulus patterning upon reaction time (RT) performance and palmar skin conductance (PSC) of one S over a period of 10 consecutive days. The main findings were that: PSC was significantly more variable with an irregular signal pattern than with a regular one, RTs were significantly faster with the regular pattern, there was a non-significant trend in which high PSC values were associated with fast RTs and low PSC values with slow RTs. The results were discussed in terms of wider variations in arousal produced by irregularly occurring signals and greater learning with regular signals.

17. Annett, J. A note on Davis's refutation of the expectancy hypothesis. Quarterly Journal of Experimental Psychology, 1966, 18, 179-180.

18. Annett, J. Payoff: A neglected factor in reaction time measurement. Quarterly Journal of Experimental Psychology, 1966, 18, 273-274.

The aim of this paper is to point out some implications of implicit or explicit payoffs in reaction time experiments.

19. Archer, E. J. Identification of visual patterns as a function of information load. Journal of Experimental Psychology, 1954, 48, 313-317.

Twelve groups of six Ss each served in an experiment on target identification. The groups corresponded to the cells of a 3 x 4 factorial design having one to four bits of relevant information and zero to two bits of irrelevant information, presented to S by a single stimulus source. The S's task was to identify oscilloscope patterns by positioning four lever-action switches and to test this identification by pressing a push button. The response measure was the time required to identify 32 consecutive patterns. Errors were also recorded, but they did not vary as a function of any parameter except practice. The major findings were: (a) time to respond increases as a linear function of relevant information load, but (b) this response time was independent of amount of irrelevant information. These results were compared with those of previous studies.

20. Audley, R. J. A stochastic model for individual choice behaviour. Psychological Review, 1960, 67, 1-15.

This paper presents a stochastic model which is concerned with the interrelations of the response variables observed in choice situations. The model is not a complete theory, because it involves no assumptions about the relations between stimulus and response variables. However, for given stimulus conditions, the parameters of the stochastic process do provide a convenient summary of many aspects of behaviour in a choice situation. Furthermore, the most elementary assumptions about the way in which these parameters might vary with changed stimulus conditions lead to predictions which are in qualitative agreement with experimental findings. In a sense, therefore, the stochastic model can be regarded as a rudimentary theory of certain aspects of choice behaviour.

21. Audley, R. J., & Pike, A. R. Some alternative stochastic models of choice. British Journal of Mathematical & Statistical Psychology, 1965, 18, 207-225.

Theories of choice may be regarded as having 2 principal features: a representation of indecision and a decision rule stating the conditions which must be satisfied for a choice to occur. Three ways of representing indecision are described and evaluated. In terms of 1 of these representations, several theoretical models of choice are developed by considering the consequences of 2 kinds of decision rule. A way of determining the properties of the models is described, but is not used in more than an illustrative fashion.

22. Avant, L. L., Bevan, W., & Wing, H. Effects of varying length of stimulus series and response scale upon response latency, response uncertainty, and transmitted information. Perception & Psychophysics, 1968, 3, 449-452.

A 3 by 3 orthogonal design was employed to study the interrelations among response latency (RL), response uncertainty (E_R), and transmitted information (I_t). Nine groups of Ss judged the size of 5, 20, or 40 projected squares in terms of 5, 20, or 40 response categories. Patterns of change E_R and RL over the three stimulus series were differentially effected by increases in the number of available response categories. The increase from 5 to 20 response categories produced, for successively longer stimulus series, a constantly increasing change in E_R; the further increase from 20 to 40 categories produced a contrasting, constantly decreasing change in E_R. The same two changes in number of response categories produced the same pattern of change in RL over the 5- and 20-stimulus series but reversed the pattern for the 40-stimulus series. Correlations between E_R and RL ranged from .28 to .99 and tended to maximize when number of response categories equaled the number of stimuli. I_t was relatively low under all conditions. Within the 5- and 20-stimulus series, increases from 5 to 20 to 40 available responses increased RL in a negatively accelerated fashion but did not increase I_t. Within the 40-stimulus series, the same increases in number of available responses produced an essentially linear increase in both I_t and RL.

B

23. Bartlett, N. R. A comparison of manual reaction times as measured by three sensitive indices. Psychological Record, 1963, 13, 51-56.

Visual reaction time data for each of 3 Ss are analyzed to show by how much the response (as recorded by a sensitive microswitch, closed by fore-arm movement) lags behind the initial application of pressure (as recorded by a strain-gauge device) and in turn by how much the latter falls behind the muscle action potential. The data afford rough corrections for translating typical reaction time data to those concerned with the initiation of the peripheral effector response.

24. Bartlett, N. R., & Bartlett, S. C. Synchronization of a motor response with an anticipated sensory event. Psychological Review, 1959, 66, 203-218.

In all the data on synchronization errors, variability tended to remain above the low figure reported for the variability in simple reactions to conspicuous visual flashes. The point can be made with confidence, particularly because one S participated in both kinds of experiments. To return to the reasoning in the introduction, the data on synchronization errors show the variability in the central triggering and motor execution independent of any variability in sensory processing but compounded instead with the variability in anticipatory mechanism. Either the latter variability is substantial, and different for an auditory-motor coordination than for visual-motor, or perhaps the entire line of reasoning is unsound. In any case, simple reactions to singly appearing strong stimuli by a well-trained, alert subject are less variable than are attempts to react in synchrony with one of a series of regularly repeated stimuli.

25. Bartlett, N. R., Sticht, T. G., & Pease, V. P. Effects of wavelength and retinal locus on the reaction time to onset and offset stimulation. Journal of Experimental Psychology, 1968, 78, 699-701.

This study measured onset and offset reaction time (RT) to a long and a short wave band in both the fovea and periphery. The wave bands were selected with the intention of isolating foveal and peripheral systems. RT to onset stimulation on the periphery is significantly faster than to offset. The difference between onset and offset RT in the fovea was not significant. On-off differences are independent of wavelength. Moreover, because a common function for intensity, independent of wavelength, existed in the periphery as well as in the fovea only when correction was made in the peripheral data for the peripheral luminosity function, it appears that those data, with their on-off differences, reflect the activity of the peripheral (rod) system.

26. Bartz, A. E. Reaction time and complexity of subsequent responses. Psychological Record, 1966, 16, 313-321.

Two series of experiments were designed to investigate the delay in reaction time (RT) as a function of S's expectancy of future responses. The 1st series (time relation) investigated the effect of lengthening the time interval between pairs of choice RTs and comparing S's response to the 1st signal with his response to a single signal. Interval was not significant and, in addition, this series failed to replicate the results of earlier investigators who found a significant delay. The 2nd series (complexity) investigated the effect of making S's multiple responses increasingly complex and comparing his 1st response of this multiple set to his response to a single signal. Complexity level was not a significant variable. However, there now was a significant difference between a single response and the 1st response of a multiple set. The results of the 2 series were interpreted as being due to a difference in S's expectancy.

27. Beck, C. H. M. Paced and self-paced serial simple reaction time. Canadian Journal of Psychology, 1963, 17, 90-97.

Experiments using tasks other than reaction time (RT) have been reported which indicate that self-pacing facilitates performance. For example, self-paced letter sorting yields a higher output than paced (Conrad, 1960). Self-paced performance, as compared to paced performance, on the pursuit rotor yields higher scores, flatter performance curves, and a reduction in the between-subject differences in performance levels (Nance, 1960). The following two experiments were carried out to determine possible differences between paced and self-paced performance in a simple serial task.

28. Becker, G. M. Sequential decision making: Wald's model and estimates of parameters. Journal of Experimental Psychology, 1958, 55, 628-636.

Subjects were permitted to secure as large a sample as they desired prior to deciding from which of several populations their sample originated. Their performance was analyzed in terms of Wald's sequential probability ratio test model, in terms of three theoretical measures— α and β error levels, hit probabilities, and criteria—and in terms of the size of the samples drawn by S prior to a decision. It was concluded that:

1. Although Wald's model does not precisely predict performance, the discrepancies are of such small magnitude as to permit the use of Wald's model as a first approximation to the human decision process. Predictions are better on difficult than on easy problems.

2. Despite equal objective costs and pay-offs, and despite equal objective probabilities, Ss show preferences for the type of error they make on easy problems. The pattern of these preferences are consistent from S to S.

3. The Ss took less risk and were more likely to be right on easy problems than they were on difficult problems. They took less risk when there were more alternative choices, but their hit probability remained essentially constant.

4. The amount of risk and size of sample preferred at the time of decision differed from S to S. The relative ordering of Ss in terms of these parameters was independent of the number of alternatives involved in the decision.

5. No S used the "ideal" game strategy.

29. Behar, I. On the relation between response uncertainty and reaction time in category judgments. Perceptual and Motor Skills, 1963, 16, 595-596.

Twelve Ss judged 10 stimulus sizes using either 10 or 2 response categories. Average RT was proportional to the $\log_2$ of the number of response alternatives. RTs for each stimulus category correlated highly with response uncertainty associated with each category.

30. Behar, I., & Adams, C. K. Some properties of the reaction time study-signal. American Journal of Psychology, 1966, 79, 419-426.

Two experiments, derived from a conditioning model of the reaction-time task, examined CS-like properties of the RT ready-signal. In the first study, the intensity of the ready-signal was varied over a range of 60 db with three different fore-periods. Both a within-Ss and a between Ss design was used. In the former, the reaction-times decreased significantly with an increase of the intensity of the ready-signal. The decrease was proportionate at each fore-period. The between-Ss conditions were not significant.

In the second study, trace and delayed presentations of the ready-signals were compared, using a within-Ss design. Delayed ready-signals yielded significantly shorter reaction-times than did trace-signals at all fore-periods. Taken together, the results of the two studies clearly indicate that the ready-signal in the reaction-time task serves more than a mere function of cuing.

31. Behar, I., & Warm, J. S. Effects of electrocutaneous ready-signal variation on visual reaction time. Perception & Psychophysics, 1967, 2, 489-490.

Two ready-signal variables (direction of change in electrocutaneous stimulation and method of presentation: "trace" or "delayed") were combined in a 2 by 2 by Ss design. Neither variable produced a significant main effect but yielded a highly significant interaction. Results were interpreted in terms of arousal, intersensory, and conditioning explanations of ready-signal effects.

32. Berlyne, D. E. Conflict and choice time. British Journal of Psychology, 1957, 48, 106-118.

Four variables have been suggested as determinants of degree of conflict: (1) the number, (2) the nearness to equality in strength, (3) the absolute strength, and (4) the degree of incompatibility, of competing response tendencies. The first two, but not the others, have figured in investigations relating reaction time to information theory. Three experiments were carried out to test the effects of all these variables on choice time. Two types of choice RT were recorded: first, the forced-choice RT (i.e. the traditional choice RT), for which one stimulus was presented at a time, each stimulus having its appropriate response; and second, the free-choice RT, for which two or more stimuli were presented together, S having to respond to any one of them.

The principal findings were as follows: (1) Both types of choice RT were longer when the number of alternative responses was increased. (2) Free-choice RT's were invariably longer than forced-choice RT's, confirming the influence of equality of strength. (3) Forced-choice RT's were inversely related to stimulus intensity, which was regarded as a factor influencing the absolute strength of response tendencies. Free-choice RT's were shortest at the intermediate of the three intensity levels studied and significantly longer at the highest and lowest levels. The proportion by which free-choice RT's exceeded forced-choice RT's increased with stimulus intensity. (4) Degree of physiological incompatibility did not affect free-choice RT's, although physiologically incompatible responses produced longer forced-choice RT's. (5) There were no significant differences between the RT's of S's with high and low neuroticism scores.

The expediency of continuing to include the degree of physiological incompatibility among the determinants of degree of conflict is called in question by the results. Otherwise, choice time, apart from the time taken up by eye movements, etc., which may be shorter with more intense stimuli appears to increase with degree of conflict. The results are discussed in the light of various theoretical models derived from Hull's principle of behavioural oscillation, Miller's theory of conflict, information theory, and Hebb's theory of cortical disruption.

33. Bernstein, I. H., Blake, R. R., & Hughes, M. H. Effects of time and event uncertainty upon sequential information processing. Perception & Psychophysics, 1968, 3, 177-184.

Two experiments were conducted to investigate the psychological refractory period (PRP), a delay induced into the second of two reaction times (RT) when the interstimulus interval (ISI) is short. In Experiment 1, time and event uncertainty were factorially varied by providing or not providing S with foreknowledge of the ISI and the order in which the two events would occur, respectively. ISIs of 0, 50, 100, 200 and 400 msec were used. Time and event uncertainty produced independent degradation of both RTs. Also, the second RT (RT_2) was delayed at 50 msec ISI when both time and event certainty were present. Experiment 2 attempted to replicate this latter finding using ISIs of 0, 25, 50, 75, and 100 msec. Delays in RT_2 were found for the middle three values of ISI. These results were interpreted as supporting a modified single channel theory of the PRP.

34. Bernstein, I. H., & Clark, M. H. Time sharing and intermodal information processing. Psychonomic Bulletin, 1968.

Two experiments were concerned with reaction time (RT) to a pair of stimulus events separated by a short interstimulus interval (ISI). Both experiments contrasted performance under visual-visual (V-V) and auditory-visual (A-V) sequences. The ISIs were short (0-100 msecs. for Experiment I and 0-60 msecs. for Experiment II) and time certain. The results of Experiment I, using response-certain pairings, were that second RT (RT_2 was faster for A-V as opposed to V-V sequences and differences were more consistent when Ss lacked foreknowledge of the sequence (channel uncertain) than when they had foreknowledge (channel certain). Because of the high inter-S variability in Experiment I, Experiment II was run, which involved sequential choices to respond or not, based upon the independent occurrence or nonoccurrence of channel certain events. With S_1 presented RT_2 was faster for A-V than V-V sequences, but the reverse was true for S_1 absent. Moreover, the former effect diminished under an error rate correction, but the latter effect did not. These findings suggested a "triggering" process, favoring A V sequences, operating on a "first in - first out" basis and a "channel switching" effect.

35. ..rnstein, I. H., Clark, M. H., & Edelstein, B. A. Effects of an auditory signal upon visual reaction time. Journal of Experimental Psychology, 1969, in press.

Three trained Ss participated in a visual reaction time (RT) task. The stimulus events consisted either of a visual (V), visual-auditory (VA), or auditory (A) signal, the latter serving as a catch signal not to be responded to. On VA trials, V and A were separated by interstimulus intervals (ISI) ranging from 0 to 90 msec. in 10 msec. units. RT to VA events was generally faster than RT to a V event alone, and was directly related to ISI. The obtained intersensory facilitation supported previous findings by Hershenson (1962) and Morrell (1968a). Also, an index of facilitation previously employed by Hershenson (1962) was obtained and, as with Hershenson's (1962) study, was an inverted U-shaped function of ISI. Discussion was directed towards an explanation of the mechanism of intersensory facilitation.

36. Bernstein, I. H., Clark, M. H., & Edelstein, B. A. Intermodal effects in choice reaction time. Journal of Experimental Psychology, 1969, in press.

Two-alternative visual choice reaction times (RTs) were obtained from each of 4 trained Ss. The RTs were obtained to the choice event alone (RT_V) or to the choice event followed by a 10-msec. $1KH_z$ sinusoidal tone burst (RT_{VA}) which could occur at any of 20 interstimulus intervals (ISIs) separating V and A, 0-190 msecs. in 10-msec. steps. RT_{VA} was a monotonically increasing function of ISI with $RT_{VA} < RT_V$ at short ISIs.

37. Bernstein, I. H., & Reese, C. Behavioral hypotheses and choice reaction time. Psychonomic Science, 1965, 3, 259-260.

Three trained Ss participated in a choice reaction time task under conditions of 0, 1, 2 and 3-bits of stimulus uncertainty. Stimuli were presented in random sequence. Prior to each presentation Ss were required to state a behavioral hypothesis, i.e., guess which stimulus event would occur. The stimulus uncertainty-choice reaction time relationship was linear, confirming previous findings. However, when correct and incorrect behavioral hypothesis trials were separately analyzed, it was found that the positive linear relation was obtained only in the latter case; choice reaction time was independent of stimulus uncertainty when S's guess was correct.

38. Bernstein, I. H., & Reese, C. Choice reaction time and behavioral hypotheses: The effects of learning sequential redundancies. Psychonomic Science, 1967, 9, 189-190.

Eleven Ss learned the sequential redundancies present in a choice reaction time (RT) task, as inferred from their ability to verbally anticipate the stimulus event to a designated criterion. These Ss showed a transition from choice to simple RT. Five Ss did not learn the redundancies to this criterion. Except for a first trial RT decrement, they behaved as did a control group of eight Ss in remaining at the choice RT level. The results suggested a technique useful in the study of cognitive determinants of RT.

39. Bernstein, I. H., Schurman, D. L., & Forester, G. Choice reaction time as a function of stimulus uncertainty, response uncertainty, and behavioral hypotheses. Journal of Experimental Psychology, 1967, 74, 517-524.

Two studies were concerned with the effects of stimulus and response uncertainty upon reaction time (RT). In Experiment I, it was found that changes in stimulus uncertainty produced linear changes in RT but changes in response uncertainty produced a step function with a maximum at 1 bit of response uncertainty. Correct pretrial guesses as to which stimulus event would occur tended to facilitate RT only in the more complex response-uncertainty conditions. Experiment II replicated the finding that stimulus uncertainty per se is a variable effecting RT. The results were discussed relative to the role of attention and response conflict.

40. Bernstein, I. H., & Segal, E. M. Set and temporal integration. Perception & Psychophysics, 1968, 4, 233-236.

An experiment was conducted to explore the temporal structure of set formation in a complex reaction time (RT) task. On each trial an instruction (I-event) was given telling Ss whether identify of color or form on a separately presented alternative display (A-event) was the dimension relevant on that trial. The A-event consisted of a pattern of four colored forms. The two forms on one side were matched for color and on the other side for form. S's task was to depress one of two keys. The correct key was homolateral to the matched relevant dimension. The basic independent variable was the time interval separating the I- and A-events (ISI). At short ISIs, RT was a linear function of ISI with slope equal to -0.5 RT was independent of the order in which the events occurred at short ISIs, although at longer ISIs (3 sec) RT was longer when the A-event followed the I-event. Also, RT was shorter at short ISIs when color was the relevant dimension rather than form, although this difference disappeared at longer ISIs. The results were discussed in relation to information processing models and previous research dealing with partial advance information.

41. Bertelson, P. Sequential redundancy and speed in a serial two-choice responding task. Quarterly Journal of Experimental Psychology, 1961, 13, 90-102.

The task used is a self-paced 2-choice serial responding task, involving two neon lamps as signals and two response keys in simple spatial correspondence with the signals. In Experiment I, three conditions with respectively 1/4, 1/2 and 3/4 alternations between successive signals were compared. It appeared that subjects go faster with 1/4 than with 3/4 alternations. From the point of view of information theory, both conditions present the same amount of information per signal. The asymmetry in the effects of both forms of sequential redundancy could be attributed either to some bias in the expectations of the subjects or to some inertia phenomenon favouring responses to repeated signals. It was reasoned that if the last explanation was true, the asymmetry would be reduced if a time-lag was introduced between end of response and appearance of next signal. This was done for one group of subjects in Experiment 2. These subjects worked on the same three conditions, with a time-lag of 0.5 sec. The asymmetry was significantly reduced when compared with another group of subjects who worked with the same 0.05 sec. time-lag as in Experiment I. Analysis of separate RTs confirmed the main conclusion that choice processes involve a transitory residual effect favouring repetitions.

42. Bertelson, P. S-R relationships and reaction times to new versus repeated signals in a serial task. Journal of Experimental Psychology, 1963, 65, 478-484.

Previous experiments showed that, in a serial responding task, RTs to repeated signals are longer than RTs to new signals. The influence of S-R relationships on this phenomenon was examined. In Experiment I, 9 Ss gave 550 responses under each of 3 S-R conditions in a 2-choice task with a spatial display. RTs to both repeated and new signals were significantly (.01) affected by the conditions, but covariance analysis shows that the effect is significantly (.05) larger on RTs to new signals. These results are fully confirmed by Experiment II were 33 Ss, after prolonged practice on a 4-choice task with a numerical display, under a straightforward S-R pairing, did 4 short runs of 50 responses under the same pairing and then under a less compatible one.

43. Bertelson, P. Serial choice reaction-time as a function of response versus signal-and-response repetition. Nature, 1965, 206, 217-218.

44. Bertelson, P. Central intermittency twenty years later. Quarterly Journal of Experimental Psychology, 1966, 18, 153-163.

The objective of this lecture will be to examine the developments up to now of one of the most influential ideas launched by Craik, the idea of intermittency in human sensory-motor activity.

45. Bertelson, P. The refractory period of choice reactions with regular and irregular interstimuli intervals. Acta Psychologica, 1967, 27, 45-56.

On each trial, two successive choice reactions, each a two-choice one, had to be given to visual stimuli. The stimuli were separated by time intervals (ISIs) ranging from 0 to 500 msec which were presented in both a predictable (regular condition) and an unpredictable way (irregular condition). Efforts were made, through instructions and the provision of knowledge of results, to have the Ss give priority to speed in the first reaction. Six Ss gave more than 2000 trials each, in ten successive sessions. No tendency to wait for the second stimulus was observed. Clear delays, negatively correlated with ISI duration, were observed in the second reaction at short ISIs, with both predictable and unpredictable ISIs. Time uncertainty is thus not a necessary condition for the production of such delays. The relationship between RT_2 and the interval between the arrival of the second signal and the end of RT_1 suggest: (a) that the central mechanisms are occupied by the first reaction for a time which lasts longer than RT_1, which is in agreement with Davis' suggestion of a central recovery time; (b) that this central recovery time is variable; (c) that the occupation by the first reaction is not total, and that some residual capacity is still available during the refractory period to deal with the second signal.

46. Bertelson, P. The time course of preparation. Quarterly Journal of Experimental Psychology, 1967, 19, 272-279.

The time course of the adjustments triggered by a warning signal was studied by measuring choice reaction times (RTs) at different predictable foreperiods after such a signal. Before the warning signal, a high time uncertainty situation was created by imposing either a long constant foreperiod of 5 sec. or one varying in the range 1.5 to 5 sec. The warning signal was a click. Foreperiods ranging from 0 to 300 millisec. were used in different blocks of trials. The stimulus was the onset of one of two lamps calling for the pressing of one of two keys. A control condition, without click, was used also. RTs were found to decrease continuously when the foreperiod was increased from 0 to 100-150 millisec. The click delivered simultaneously with the stimulus permitted reactions significantly faster than in the control condition. It is concluded (a) that the latency of preparation can be much shorter than the 2 to 4 sec. reported by Woodrow, (b) that the warning signal can be used as a time cue to start preparatory adjustments without starting a refractory period of the order of magnitude found in experiments with pairs of successive reactions, and thus that such refractory periods are not the inevitable cost of paying attention to a signal. There is also some suggestion that in this situation the click not only triggers preparatory adjustments, but also causes an immediate facilitation of the reaction to the visual stimulus.

47. Bertelson, P., & Barzeele, J. Interaction of time-uncertainty and relative signal frequency in determing choice reaction time. Journal of Experimental Psychology, 1965, 70, 448-451.

Choice RTs to 2 signals of relative frequencies .2 and .8 were measured under 2 time-uncertainty conditions: constant FPs of either .5 or 5.0 sec. The RT to the more frequent signal is more affected by time uncertainty than the RT to the less frequent one. This result shows that "preparation," a hypothetical state which has often been postulated to account for time-uncertainty effects, is at least in part specific to one particular signal-response pair, or, alternatively, that the well- known effect of signal relative frequency is affected by very short-term fluctuations.

48. Bertelson, P., & Boons, J. Time uncertainty and choice reaction time. Nature, 1960, 187, 531-532.

49. Bertelson, P., & Borsu, M. Incertitude temporelle et reconnaissance tachistoscopique. [Temporal uncertainty and tachistoscopic recognition]. Annee Psychologique, 1965, 65, 17-26.

This paper shows that tachistoscopic recognition, unlike reaction time (R.T.) is unaffected by time uncertainty as to the moment of occurrence of the stimulus.

In Experiments 1 and 2, pairs of letters from a possible sub-set of 12, were presented at a duration equal to the previously determined threshold of the subject. Performance (% correct) was no better with constant foreperiods (F.P.) of 600 ms than with F.P. varying over the range 200-1200 ms (Exp. 1) or than with either a constant F.P. of 4600 ms or F.P. varying over the range 600-4600 ms (Exp. 2).

In Experiment 3, tachistosopic recognition and choice R.T. were studied in parallel, with the same conditions as in Exp. 2. Both tasks involved the choice between four possible letters of the alphabet. Four subjects participated in 11 sessions each. As in previous experiments, R.T. was significantly shorter with the short constant F.P. than with either the long constant or the variable F.P. Recognition was equal under the three conditions.

In terms of Broadbent's information flow model, these results mean that storage of the stimulation in the S system is not influenced by time uncertainty, which only affects later stage of the information-processing mechanisms. This conclusion is shown to be compatible with the results of Treisman and Howarth and of Egan and al., who demonstrated that signal detection is affected by time-uncertainty.

50. Bertelson, P., & Davidson, A. A simple two-channel programming unit permitting the control of conditional probabilities. Quarterly Journal of Experimental Psychology, 1959, 11, 180-184.

51. Bertelson, P., & Joffe, R. Blockings in prolonged serial responding. Ergonomics, 1963, 6, 109-116.

The data from a former experiment with a serial responding task were analysed to throw light on some issues connected with the 'blocking' phenomenon. The task consisted of pushing one of four keys in response to the appearance of four figures on a numerical indicator. It was self-paced. Thirty-five subjects worked on it uninterruptedly for 30 min. It is shown that:

1. The main change which occurs in the distribution of reaction times during the session is the appearance of a tail of long times: this is in agreement with the blocking hypothesis, i.e., with the hypothesis that an extra delay is sometimes added to the normal reaction time.

2. The increase in number of long reaction times takes place in the first five minutes of work.

3. Long reaction times are preceded by an increase in mean reaction time and in percentage of errors, which take place over four or five preceding responses, and are followed by a return of both variables to normal level; this is in agreement with the hypothesis that blocks allow fatigue to dissipate.

52. Bertelson, P., & Renkin, A. Reaction times to new versus repeated signals in a serial task as a function of response-signal time interval. Acta Psychologica, 1966, 25, 132-136.

Previous experiments showed that serial choice RT is longer on the trials where the stimulus is different from the preceding one. The influence on this phenomenon of the duration of the time-lag between the end of the response and the arrival of the next signal was examined. Sixteen Ss gave 600 responses on each of 4 sessions on a self-paced two-choice task, where they responded with one of two keys to the presentation of one of two shapes. Response-signal intervals of 50, 200, 500 and 1000 msec were presented, following both a regular and an irregular procedure. Under both procedures, the difference between RTs to new and two repeated stimuli was shown to decrease with the passage of time.

53. Bertelson, P., & Tisseyre, F. Choice reaction time as a function of stimulus versus response relative frequency of occurrence. Nature, 1966, 212, 1069-1070.

54. Bertelson, P., & Tisseyre, F. The time-course of preparation with regular and irregular foreperiods. Quarterly Journal of Experimental Psychology, 1968, 20, 297-300.

A previous experiment (Bertelson, 1967) had shown that the temporal information brought by a warning signal affected RT even after very short foreperiods (FPs). The present experiment was carried out to examine whether this result was contingent on the predictability of the FP. After a 5 sec. waiting delay, the subject heard a warning click which was followed after a predictable (regular procedure) or unpredictable FP (irregular procedure) by the visual signal calling for a choice reaction. The range of FPs was 0-300 msec. again. The time course of the adjustments triggered by the click was found to be similar under both procedures. The main conclusion is that a shift from preparation to reaction can occur at any time and need not be programmed before preparation is started.

55. Bertelson, P., & Tisseyre, F. Refractory period of c-reactions. Journal of Experimental Psychology, 1969, 79, 122-128.

On each trial the presentation of a letter calling either a key-pressing response or abstention (Donders' c-reaction) was followed, after an inter-stimulus interval (ISI) varying at random over the range 0-700 msec., by the onset of one of two lamps calling for the pressure of one of two keys. The problem was to know if the second reaction would be delayed more after positive than after negative first stimuli. Experiment I, where two stimuli, one positive and one negative, were used for the c-reaction, gave ambiguous results. It seemed possible that the instructions and the payoff system had led some Ss to prepare selectively for the positive stimulus. To make this strategy more difficult, four stimuli, two negative and two positive, calling for the choice between one of two keys, were used for the c-reaction in Exp. II. Each of the four Ss had longer delays after the positive first stimuli. It was concluded that analysis of the stimulus and execution of the response contribute independent components to the refractory period. Also, the data from the positive trials were found to be in general agreement with a single channel interpretation of refractoriness but not with the strong version assuming no overlap of occupation times, and confirmed earlier suggestions that some residual capacity is still available during the refractory period.

56. Bertelson, P., & Tisseyre, F. The time course of preparation: Confirmatory results with visual and auditory warning signals. Acta Psychologica, 1969, in press.

In a previous experiment (Bertelson, 1967), an auditory warning signal occurring in a high time-uncertainty situation produced an acceleration of the choice reaction to a visual stimulus which followed it by a predictable interval. The experiment has been replicated with the same click as warning signal in one condition, and with a visual signal, a flash, in the other condition. The facilitating effects of the flash lag behind those of the click, but they are observed for all positive intervals and are significant from 70 msec. onwards. The previous conclusion that a warning signal can be used as a time cue without starting a refractory period was thus not restricted to the particular signal which had been used so far. A consequence is that the current tendency to take the situation of a reaction stimulus prefaced by a no-reaction stimulus as the standard condition in which to study refractoriness should be considered with caution.

57. Bevan, W., Avant, L. L., & Lankford, H. G. Serial reaction time and the temporal pattern of prior signals. American Journal of Psychology, 1966, 79, 551-559.

This experiment examined the relationship between response-latency to serially-presented simple visual signals and the frequency-distribution of presentation-intervals within the stimulus-series, when mean duration, range of duration, and the number of different sized intervals was held constant. A total of 200 Ss (men) were tested with the following types of distributions: constant interval; normal variable interval; skewed variable interval; bimodel variable interval, and rectangular interval. No differences among the series means were obtained for any of the distributions. Response-times were shortest, however, for the mean as compared to the other intervals used in the adaptation-series. Ss also were given one additional test-trial. Response-latencies were shortest when this test-interval corresponded to the mean of the series, and was longer as the test-interval deviated from the mean. Again, the statistical structure had no relationship to response on the test-trial. Variability of response differed among the several types of distribution but the significance of this variability is obscure. These results emphasize the role of the mean interval -- in contrast to the statistical shape of the interval program -- as a determinant of the occurrence of signals on successive trials.

58. Bevan, W., & Avant, L. L. Response latency, response uncertainty, information transmitted, and the number of available judgmental categories. Journal of Experimental Psychology, 1968, 76, 394-397.

The interrelations among response latency and 2 informational measures, response uncertainty (E_r) and information transmitted (I_t), were studied in 6 independent groups. All Ss made categorical size judgments of the same series of 10 squares, but different groups made judgments in terms of response scales containing 2, 4, 8, 16, 32, and 64 categories. Mean response latency was lowest in the 2-category situation and increased with each increase in number of categories to the limit used (64). E_r increased as number of available categories increased to 32 but did not change substantially beyond this point. I_t increased until number of categories approximated the number of stimuli but was little affected by further increases in scale complexity.

59. Bevan, W., Bell, R. A., & Taylor, C. Changes in response latency following shifts in the pitch of a signal. Journal of Experimental Psychology, 1966, 72, 864-868.

A set of three experiments, involving a total of 516 Ss, examined response latencies to a tone following an adaptation series of 20 tones. The results indicate response time to increase to a maximum as the pitch of the test tone differed from the pitch, or average pitch, of the preceding series. Larger differences resulted in a return of the response latency to the level of the series. Increases in latency were greater following a variable-pitch than following a constant-pitch series. In addition, changes in latency were found to be minimal when the pitch of the test signal coincided with the mean, as compared to the mode or midrange, of the adaptation series.

60. Bevan, W., Hardesty, D. L., & Avant, L. L. Response latency with constant and variable interval schedules. Perceptual and Motor Skills, 1965, 20, 969-972.

Twelve independent groups were used to examine the relationship between latency and regularity of signal occurrence. In each of 6 groups 20 simple visual signals were presented sequentially at one of 6 constant intervals. Interval durations were 10, 20, 40 80, 160 or 320 sec. For each constant-interval group tested, there was also a variable-interval group with intervals of the same average duration. For all intervals except one (40 sec.), the variable-interval groups had longer response latencies than the constant-interval groups, the difference in response latency between the constant- and variable-interval groups increasing as a function of the duration of the interval, up to intervals of 160 sec. For both constant- and variable-interval groups, response latency varied directly with interval duration.

61. Biederman, I. Human performance in contingent information processing tasks. Human Performance Center, University of Michigan, Technical Report No. 3, 1966.

Theoretical accounts of complex human information processing behavior have emphasized the utilization of contingencies whereby the processing of some information directs the processing requirements of the remaining sources of uncertainty. The manner in which such contingencies are processed, however, has received little empirical study. The present investigation examined the effects of discriminability and S-R compatibility on the speed and accuracy of response in tasks in which the relevancy of a given stimulus dimension was contingent upon the value of the stimulus on some other dimension.

62. Biederman, I., & Sterns, H. L. The effects of redundant, relevant information and stimulus probability on choice reaction time. Psychonomic Bulletin, 1967, 1, (No. 2), 6.

When stimuli differ on two dimensions, either of which can furnish sufficient information for correct identification, RTs are faster than when stimuli differ on only one dimension. The results support a model of parallel processing of different dimensions but serial processing of the values within a dimension.

63. Bindra, D., Donderi, D. C., & Nishisato, S. Decision latencies of "same" and "different" judgments. Perception & Psychophysics, 1968, 3, 121-130.

When a subject is asked to judge whether two stimuli are "same" or "different," the time he takes to reach the decision same is frequently unequal to the time he takes to reach the decision different. We studied this discrepancy as a function of several variables, including stimulus modality, "codability" vs. "noncodability" of test stimuli, interstimulus interval, and discrimination difficulty. Results of four different experiments performed on a total of 171 subjects showed codability and discrimination difficulty to be the most important factors. Stimuli that are codable (i.e., which can be categorized by absolute judgment) yield a shorter latency for decision same, and noncodable stimuli (i.e., those requiring a reference stimulus for categorization) yield a longer latency for decision same. The modality of test stimuli, the prothetic or metathetic nature of the dimension to be judged, and simultaneous vs. successive presentation of the stimuli appear not to be crucial factors.

64. Bindra, D., Williams, J. A., & Wise, J. S. Judgments of sameness and difference: Experiments on decision time. Science, 1965, 150, 1625-1627.

When asked to judge whether two stimuli (tones) were the "same" or "different," subjects took longer to decide that two identical stimuli were the same than to decide that two dissimilar stimuli were different. Thus these judgments are not equivalent obverse aspects of a unitary judgmental process. While decision theory can be extended to deal with the obtained data, a model based on an analogy with a statistical computer is more directly applicable.

65. Birch, D. Competition and coordination between the verbal and motor systems: Simple reaction time. Psychonomic Bulletin, 1967, 1,(No. 2), 6.

Subjects performed both a simple motor and a simple vocal response to a light signal under payoff conditions that rewarded fast motor responding. Groups differed in the criterion set for the latency of the vocal response. Results showed evidence of competition and coordination between these peripherally compatible motor and verbal activities.

66. Birren, J. E., & Botwinick, J. Speed of response as a function of perceptual difficulty and age. Journal of Gerontologia, 1955, 10, 433-436.

This study was designed to determine to what extent perceptual difficulty was a variable in age changes in response latency. Young and elderly subjects were required to judge which of two simultaneously presented lines was the shorter. Each subject made a minimum of 48 judgments in a series of line pairs which differed in length from 1 to 50%. The subjects were all healthy males. The young group of 30 individuals was between the ages of 19 and 36 years. The 43 elderly subjects were between the ages of 61 and 91 years. The response time of the elderly subjects was significantly slower at all levels of difficulty but was greatest for the most difficult comparisons.

67. Blackman, R. The effect of the orienting reaction on disjunctive reaction time. Psychonomic Science, 1966, 4, 411-412.

Eighty Ss performed a visual or auditory disjunctive reaction time (DRT) task in which some of the task stimuli were preceded, at irregular intervals, by an intense visual or auditory "orienting stimulus." Initially the orienting stimuli impaired speed of response, but on subsequent presentations produced shorter DRTs than when no orienting stimulus was given. It is suggested that the warning signal used in RT experiments may influence performance not only as a result of the information it carries, but also because it may elicit an orienting reaction.

68. Blake, R. R., & Fox, R. Visual form recognition threshold and the psychological refractory period. Perception & Psychophysics, 1969, 5, 46-48.

Two experiments studied the effect of a reaction time response (RT) on visual form recognition threshold when the temporal interval separating the RT stimulus and the recognition stimulus was short. In Experiment 1 an initial RT response to an auditory signal did not impair the subsequent forced-choice visual form recognition threshold. Interstimulus intervals (ISI) of 0, 50, 100, 150, and 200 msec were used; S was always aware of the ISI under test. In Experiment 2 a visual stimulus was used to elicit the RT response; this shift to an intramodal stimulus did not alter the recognition threshold. These data were interpreted as supporting the hypothesis that two stimulus events can be processed simultaneously even when the temporal interval between them is short.

69. Boies, S. J., Posner, M. I., & Taylor, R. L. Rehearsal of visual information from a single letter. Paper presented at the Meeting of the Western Psychological Association, San Diego, Calif., 1968.

70. Boons, J. P., & Bertelson, P. L' influence de l'incertitude temporelle sur le temps de reaction de choix. [The influence of temporal uncertainty on choice reaction-time situations] Annee Psychologie, 1961, 61, 361-376.

In simple reaction time, length and variability of the preceding period are influential. In choice reaction-time situations, time uncertainty affects reaction time.

71. Borger, R. The refractory period and serial choice-reactions. Quarterly Journal of Experimental Psychology, 1963, 15, 1-12.

An experiment is described in which subjects had to make consecutive 2-choice reactions to light and sound stimuli, the interval between signals being fixed for any one series of presentations. When under these conditions, reaction times to the second signal are compared to those obtained when the first signal is used only as a warning, delays are found for short intervals These results and the wide individual differences obtained are discussed in relation to theories that have been put forward to account for the delays obtained in serial reaction tasks.

72. Borghi, J. H. Distribution of human reaction time. Perceptual and Motor Skills, 1965, 21, 212-214.

Over 4,000 RTs were collected for one S in a 5-month period. A normal distribution was approximated for the particular sensory-motor link studied.

73. Botwinick, J. Joint effects of stimulus intensity and preparatory interval on simple auditory time. Journal of Experimental Psychology, (1969), in press.

RTs were measured in relation to two regular preparatory intervals (PI) within three stimulus intensity levels. The intensities were set at approximately the 75 per cent absolute threshold, the 100 per cent threshold, and at a much higher level for each of 48 Ss. This corresponds to approximate mean db levels of 6, 8 and 81 respectively. The PIs were 0.5 and 6.0 sec. RTs were found to decrease with increased intensity and to be related to the PI in the usual way only in the two higher intensity conditions. The combination of the lowest intensity tone and the least time to get set for it, made for the very slowest RTs. Inter-S variances were large in the condition of lowest intensity stimulation.

74. Botwinick, J., & Brinley, J. F. An analysis of set in relation to reaction time. Journal of Experimental Psychology, 1962, 63, 568-574.

Principal component analyses were performed with reaction times (RTs) in relation to preparatory intervals (PIs) in six different series. Components of general RT level or RT set were found on which all PIs loaded substantially. In addition, short-interval components were found when matrices were rotated orthogonally. Long-interval components were not found, nor were other identifiable components. The results were discussed in relation to the hypothesis that aspects of RT set were distinguishable, different in meaning, and independent.

RTs were related to both the PI and its specific context. While RT level was different for auditory and visual stimulation, the differences was not related to PI or its context. Thus, set, as inferred from the relation between RT and PI, was independent of sense modality.

75. Botwinick, J., Brinley, J. F., & Robbin, J. S. The interaction effects of perceptual difficulty and stimulus exposure time on age differences in speed and accuracy of response. Gerontologia, 1958, 2, 1-10.

Male volunteer Ss in 2 age groups were studied to determine the effects of a reduced stimulus exposure duration upon the functional relation between the difficulty of a discrimination task and age differences in accuracy and latency of response. The Ss judged which of 2 simultaneously presented lines was the shorter. The lines were tachistoscopically presented for 2.00 seconds, at 6 different levels of difficulty. The task was then repeated with a 0.15 second stimulus exposure duration. Response latency and errors increased with stimulus difficulty. Latencies and accuracies were decreased with the reduced stimulus exposure duration. The largest reductions in latency were for the older group with the most difficult discrimination.

76. Botwinick, J., Brinley, J. F., & Robbin, J. S. Maintaining set in relation to motivation and age. American Journal of Psychology, 1959, 72, 585-588.

Simple auditory RT was measured in relation to preparatory intervals (PI) in both irregular and regular series for Ss in two age-groups and under two conditions of motivation. Median ages of the two groups were 25 and 72 years. One condition of motivation involved verbal instruction to respond as quickly as possible. A second condition involved a mild shock to the wrist for RTs slower than individual median non-shock RT.

The results indicated that with longer PIs, RTs of the elderly group relative to those younger group tended to be slower with regular series than with irregular series. It was concluded that the younger group maintained set better than did the older group. Shock-motivation decreased RT but had no significant effect on the set-phenomenon.

77. Botwinick, J., & Thompson, L. W. Premotor and motor components of reaction time. Journal of Experimental Psychology, 1966, 71, 9-15.

Reaction time (RT) was fractionated into premotor and motor components based upon the difference between EMG and finger-lift responses. EMGs were recorded from the extensor muscle of the responding forearm during measurement of simple auditory RTs of 54 Ss. The premotor time was that period from the presentation of the stimulus to the appearance of increased muscle firing, while the motor time was that period from this change in action potential to the finger-lift response. Four preparatory intervals (PI), 0.5, 3.0, 6.0, and 15.0 sec., were used in both a regular and irregular series. Premotor time and RT were highly correlated and showed comparable variations as a function of PI and type of series. Motor time was poorly correlated with RT and was independent of PI and type of series. It was concluded that set, as inferred from the relations between RT and PI and type of series, is a premotoric process.

78. Botwinick, J., & Thompson, L. W. Components of reaction time in relation to age and sex. Journal of Genetic Psychology, 1966, 108, 175-183.

Reaction time was segmented into two component parts, premotor time and motor time. The reaction times and the components were analyzed in relation to four preparatory intervals within an irregular series and a regular series. These functions were then compared among subgroups comprising elderly males, elderly females, young adult males, and young adult females. The reaction times were segmented by the method of Weiss (9). Electromyograms were recorded from the extensor muscle of the responding forearm during measurement of reaction time. The time between stimulus presentation and occurrence of increased muscle firing was the premotor time; the motor time was the reaction time minus the premotor time.

Premotor times, motor times, and, therefore, reaction times were found to be slowed in advanced age. Interactions between age and sex were not significant (p .05), indicating that whatever the antecedent mechanisms of the slowing process with advanced age may be, they may be the same for men and women.

79. Botwinick, J., & Thompson, L. W. A research note on individual differences in reaction time in relation to age. Journal of Genetic Psychology, 1968, 112, 73-75.

Typically, old adult Ss vary more among themselves with respect to reaction time (RT) than do young adult Ss, but it was argued that this may be due to the different preparatory intervals (PIs) in the RT series. Variations in PIs make for greater variations in RTs of older Ss than younger ones. To determine whether RT variances of the old are greater than those of the young, independent of PI variations, age comparisons were made within each of the following PI durations in both regular and irregular series: .5, 3.0, 6.0, and 15.0 seconds. Holding PI constant in this manner, the RT variances were still greater for the old than for the young.

80. Bradshaw, J. L. Pupillary changes and reaction time with varied stimulus uncertainty. Psychonomic Science, 1968, 13, 69-71.

In a reaction-time task, an increase in stimulus uncertainty led to increased RT. This was achieved by varying the number of possible sensory modalities for the signal, changing the length or variability of a warning foreperiod, and concurrently presenting masking noise. At the highest levels of uncertainty, concurrently-monitored pupillary dilation showed an overall flattening of associated response peaks, together with a rise in baseline levels. There was also evidence of expectancy phenomena with nonoccurring, anticipated signals.

81. Bradshaw, J. L. Background light intensity and the pupillary response in a reaction time task. Psychonomic Science, 1969, 14, 217-254.

In an auditory reaction time task, changes in pupillary dilation were monitored during conditions of high and low background illuminations. The latter were found to determine pupillary baseline levels, while the amplitude of the dilation peak at response stayed at a constant value. Unfulfilled expectancy that a response signal would occur was found to induce a smaller expectancy peak, despite the absence of an associated motor response. It was confirmed that temporal uncertainty relating to the length of the warning foreperiod could partly determine the Ss' RT performance.

82. Brainard, R. W., Irby, T. S., Fitts, P. M., & Alluisi, E. A. Some variables influencing the rate of gain of information. Journal of Experimental Psychology, 1962, 63, 105-110.

This study investigated the effects on information processing of (a) the use of self-paced serial reactions vs. discrete reactions, and (b) the use of different stimulus and response codes (both numerals and lights were used as stimuli, and both vocalizations and finger movements were used as responses), and (c) the use of three levels of stimulus uncertainty (ranging from 1 to 3 bits/stimulus in unit steps). These several conditions, and the use of naive Ss, provided further tests of the generality of the function, $RT = a + b(H_t)$.

The results were: (a) Reaction time (RT) was an increasing linear function of the average amount of information transmitted (H_t) per stimulus-response event for three of the four S-R pairings employed. The RTs obtained for vocal responses to Arabic numerals, however, were affected only slightly by number of alternatives in the range from 2 to 8. (b) The self-paced and discrete tasks gave very similar results. There was a slight tendency for the discrete reactions to be made more accurately but more slowly than the self-paced serial reactions, but the differences both in RT and H_t were small and compensating. The linear functions relating RT with H_t were essentially identical for the two modes of stimulus presentation.

These findings are interpreted as indicating the importance of overlearning in determining S-R compatibility effects. The findings also suggest that S's familiarity in dealing with specific subsets drawn from familiar alphabets may also affect his information-handling rates, when restricted subsets of stimuli and responses are used.

83. Brebner, J. Continuing and reversing the direction of responding movements: Some exceptions to the so-called "psychological refractory period." Journal of Experimental Psychology, 1968, 78, 120-127.

Delays in responding to a signal to continue or to reverse the direction of a response movement were calculated where the signal arrived shortly before the response movement to a prior signal began. The results indicate that the processing of signals conveying instructions to continue a responding movement is not delayed even when the 2nd signal arrives during RT1. More surprisingly, without being entirely conclusive, the data suggest that signals to reverse the direction of movement may also be processed without delays. This evidence indicates the selective nature of the "gating process," by which ongoing activity of the decision mechanism is assumed to be protected from the arrival of further signals.

84. Brebner, J., & Gordon, I. Ensemble size and selective response times with a constant signal rate. Quarterly Journal of Experimental Psychology, 1962, 14, 113-116.

Using a selective response task in which subjects were required to respond only to one of a number opf alternative digits, although signal rate was held constant, the latency of selective responses was found to lengthen as the number of alternatives increased. This finding does not support the inference drawn from the work of Mowbray (1960) that, with signal rate held constant, there should be no significant lengthening of reaction times as the ensemble of digits increases.

85. Brebner, J., & Gordon, I. The influence of signal probability and the number of non-signal categories on selective response times. Quarterly Journal of Experimental Psychology, 1964, 16, 56-60.

Signal probability and the number of non-signal categories were varied independently in a selective response task. Response latencies were significantly affected by changes in signal probability but not by changes in the number of non-signal categories.

86. Bricker, P. D. Information measurement and reaction time: A review. In H. Quastler (ed), Information Theory in Psychology. Glencoe, Illinois: The Free Press, 1955.

87. Bricker, P. D. The identification of redundant stimulus patterns. Journal of Experimental Psychology, 1955, 49, 73-81.

The purpose of this study was to observe the effect of two major variables, stimulus redundancy and response uncertainty, on the process of identifying stimuli composed of binary elements. The rate at which a list of eight stimuli was learned and the reaction time required for identifying the stimuli were used as measures of the identification process. Stimulus redundancy was varied by adding elements to the minimum number of elements necessary to identify each stimulus. This theoretically provided S with alternative ways to identify the stimuli. Response uncertainty was varied by changing the number of responses available to S, thereby changing the number of stimuli to which each response referred. A third variable consisted of deleting one element from 10% of the stimuli presented to half of the Ss. This deletion variable was introduced to test the effect of stimulus redundancy on the accuracy of responses to incomplete stimuli.

Stimulus redundancy retarded learning, by making the stimulus patterns more complex and difficult to identify, and slightly increased reaction time. In this form, redundancy cannot be considered a important aid to stimulus identification. The Ss using redundant stimuli, however, were more accurate on incomplete stimuli than those whose stimuli were nonredundant.

Response uncertainty had no consistent effect on the rate of learning, but was related positively to reaction time. The relative importance of stimulus and response factors in this relationship is discussed.

88. Briggs, G. E., & Blaha, J. Memory retrieval and central comparison times in information processing. Journal of Experimental Psychology, 1969, 79, 395-402.

Memory load and display load were varied orthogonally in a simple information-reduction task which required S to respond either "yes" or "no" that a visual display does or does not contain an item previously memorized. Twelve Ss were given extended (12 days) practice. Reaction time was a linear function of memory load, and the slope constants of that relationship were a linear function of display load for positive responses and a power function of display load for negative responses. The fitted equations provided indexes of memory retrieval time and central comparison time separately. These times decreased systematically with practice. It was concluded that throughout S performed an exhaustive serial comparison process with display rechecking prior to a negative response.

89. Brindley, G. S., Carpenter, R. H. S., & Rushton, D. N. Reaction times for simple shape discriminations requiring one or both visual cortices. Quarterly Journal of Experimental Psychology, 1967, 19, 70-72.

Reaction times for a simple two-choice shape discrimination requiring either one or both visual cortices were measured.

In a total reaction time of around 400 millisec. the difference found was 3.0 ± 2.6 millisec. if subjects were weighted according to number of observations, and 1.34 ± 1.68 millisec. if they were weighted according to reciprocals of variances of differences of means; that is, it was not significant.

90. Broadbent, D. E., & Gregory, M. Donders' b- and c-reactions and S-R compatibility. Journal of Experimental Psychology, 1962,, 63, 575-578.

91. Broadbent, D. E., & Gregory, M. Human responses to classes of stimuli. Nature, 1962, 193, 1315-1316.

92. Broadbent, D. E., & Gregory, M. On the interaction of S-R compatibility with other variables affecting reaction time. British Journal of Psychology, 1965, 56, 61-67.

Choice reactions to tactual stimulation were studied, using compatible instructions (react with the finger that is stimulated) and incompatible ones (react with the corresponding finger on the other hand). It was found that decrease in compatibility increased the effect of number of alternative reactions, of uncertainty about the time of arrival of a stimulus, of a simultaneous distracting task, and of an unequal frequency of arrival of different signals. It was also noted that no significant interaction was found between time uncertainty and number of alternative signals; and that stimuli with a fixed probability of occurrence gave slower reactions when several different stimuli were presented in intervening trials, than when there was only one. The results are interpreted as according with a theoretical mechanism resembling a statistical decision.

93. Broadbent, D. E., & Gregory, M. Psychological refractory period and the length of time required to make a decision. Proceedings of the Royal Society, B, 1967, 168, 181-193.

Three groups of men were tested in a situation involving reaction to two successive stimuli at a short known time interval. Each reaction required the choice of one of two reaction keys, depending upon the light stimulus delivered. For one group of subjects, the first reaction was made easy by making the left key correct for the left light; for the second group, the first reaction was made slower by making the left key correct for the right light. In the third group, one of the two possible stimuli for the first reaction occurred more often than the other, so that the first reaction was sometimes fast and sometimes slow.

The second reaction was delayed if the interval between stimuli was shorter than the first reaction time; in conditions where the first reaction time was longer, the second reaction time was delayed by an even greater amount. This result supports the view that a common decision-making mechanism of limited capacity is occupied by the first reaction and so is unable

to deal with the second one; two other theories of the effect seem inconsistent with the present data.

94. Brown, D. W. The effect of observer redundancy on display monitoring efficiency. Journal of Psychology, 1963, 56, 413-419.

Speed and reliability of performance were studied as a function of operator redundancy and task difficulty. Six pairs of Ss responded to 3 sets of 4 critical stimuli composed of either 2, 3, or 4 lights in a 4 x 3 matrix. Pairs of Ss were arranged for redundant and nonredundant operation. Reaction time decreased with decreasing stimulus complexity and the nonredundant situation produced lower RT's. Analysis of number and types of errors showed no significant effects.

95. Brown, I. D. Many messages from few sources. Ergonomics, 1960, 3, 159-168.

Two methods of presenting a given number of visual messages have been compared. (1) Each message was displayed by a separate source. (2) All combinations of n sources were used to display 2n-1 alternative messages. These were called Separate Sources (S) Displays and Combined Sources (C) Displays, respectively. Comparisons were made between displays of 3, 7 and 15 alternative stimuli. The criteria of efficiency were speed and accuracy of verbal response. At the 3 and 7-choice levels there was no significant difference between the rates of gain of information from the two types of display. At the 15-choice level, subjects gained information significantly more efficiently from the S display. It is concluded that C displays can be used to advantage in signalling systems which must present up to 7 alternative stimuli.

96. Buchsbaum, M., & Callaway, E. Influences of respiratory cycle on simple reaction time. Perceptual and Motor Skills, 1965, 20, 961-966.

The effect of respiration on simple auditory reaction time was studied. In the first study, reaction times and respiratory phase data were collected during spontaneous breathing; in Study 2, a warning light signaled S to hold his breath in either inspiration or expiration. Both experiments showed faster reaction times with expiration. This is contradictory to reaction time findings reported by other investigators who have studied effects of respiration.

97. Burrows, A. A. Choice response in quiet and loaded channels with verbal and non-verbal auditory stimuli. Human Factors, 1962, 4, 187-191.

Observations were made on certain verbal and non-verbal signals in quiet, noisy and in simulated RT conditions where it was required to select and to respond to up to twelve sound signals. Verbal signals appeared to be significantly better than non-verbal even where channel noise was higher than signal level. Ambient noise was not detectable as an effect because of the confounding nature of the learning curve.

C

98. Carterette, E. C. Random walk models for reaction times in signal detection and recognition. Proceedings of the XVIII International Congress of Psychology, 1966, 16, 84-95.

99. Carterette, E. C., Friedman, M. P., & Cosmides, R. Reaction time distributions in the detection of weak signals in noise. Journal of the Acoustical Society of America, 1965, 38, 531-542.

100. Chase, W. G., & Posner, M. I. The effect of auditory and visual confusability on visual and memory search tasks. Paper read at the meeting of the Midwestern Psychological Association, Chicago, 1965.

This research is concerned with the processes involved in searching through an array of letters to locate a test item. Neisser (1963) with search through visually present items and Sternberg (1963) with search through memory for previous visual items have both shown reaction time to be a linear function of the number of items to be searched. It is therefore possible, as they suggest, to use the slope of functions relating reaction time to number of items searched as a measure of the rate of the comparison process which leads to the selection or rejection of each item. This slope is uncontaminated by other processes which may affect the response; such processes being reflected in the intercept.

Previous work has not allowed direct comparisons of visual and memory search within the same experimental situation. This experiment is designed to determine the slopes for three search tasks: visual comparison, visual recognition and memory search. The processes underlying each of these tasks are explored by manipulating the degree of visual and acoustic similarity between the populations of letters employed.

101. Cheatham, P. G. Visual perceptual latency as a function of stimulus brightness and contour shape. Journal of Experimental Psychology, 1952, 43, 369-380.

In these studies perceptual latency and perceptual development time were measured as a function of changes in the brightness and the contour shape of the stimulus. Measurement was by the method of masking, which gave values of relative perceptual latency, obtained in O independently of any motor reaction time.

An inverse relationship was found between the test stimulus brightness and the perceptual latency for that stimulus.

Perceptual latencies did not, in general, vary significantly with variations in the stimulus contour. The data did not support the hypothesis that the more angular figures would have shorter latencies. Actually, angles and angular figures had the longest latencies.

Development time, measured as that time required for the complete development of the contour, was inversely related to stimulus brightness. Unlike latency, it did vary significantly with changes in contour shape.

During the developmental period the contour passed through an orderly sequence. A small portion appeared first, then increased in size, and finally became complete. Sides appeared before angles.

102. Cherry, C. (ed) Information Theory, London: Butterworth, 1960.

103. Chocholle, R. Variation des temps de reaction auditifs en fonction de l'intensite a diverses frequences. [Variation of auditory reaction times as a result of intensity at different frequencies] Annee Psychologie, 1940, 41, 5-124.

104. Christie, L. S., & Luce, R. D. Decision structure and time relations in simple choice behavior. Bulletin of Mathematical Biophysics, 1956, 18, 89-111.

The structure of simple decisions is considered in terms of a model which composes such decisions from hypothetical elementary decisions. It is argued that reaction-time data can be treated by the use of the Laplace transform so as to overcome difficulties which negated earlier attempts to analyze choice reactions. The general model leads to complex problems which are formulated but not solved. Two special cases of the model are worked out, and the statistical problem of evaluating the fit of the model is discussed. It is shown that treating decision processing as time-discrete leaves the essential features of the analysis unchanged. Two experimental proposals, to provide data which should be considered in further work on the model, are made.

105. Church, R. M., & Camp, D. S. Change in reaction-time as a function of knowledge of results. American Journal of Psychology, 1965, 78, 102-106.

The purpose of this experiment was to study the permanence of the decrease in RT produced by knowledge of results. Forty Ss were given 1250 RT-trials in a period over five days. The results were: (a) Ss with knowledge were faster than those without knowledge: (b) Ss with a warning signal of fixed duration were faster than those with a warning signal of variable duration; and (c) the RTs decreased as a function of practice. There was no evidence of any lasting effect of knowledge on subsequent performance. Knowledge of results seemed to be effective only during periods in which it was given.

106. Corballis, M. C., Lieberman, W., & Bindra, D. Discriminability and central intermittency in same-different judgments. Quarterly Journal of Experimental Psychology, 1968, 20, 51-61.

Four sets of paired visual stimuli (OO, XX, XO, or OX) were judged by 48 subjects to be either "same" or "different." Decision latencies of the same and different judgement were studied as a function of the inter-stimulus interval (ISI). In Experiments I and II, in which stimulus durations were 70 millisec., decision latencies showed increases when the ISI was reduced to100 millisec., but in Experiments III and IV, in which the stimulus durations were only 40 millisec., comparable increases did not occur until the ISI was reduced to 50 millisec. These increases were more marked for "same" than for "different" judgement , although overall decision latencies were generally shorter for "same" judgements. The effects of varying ISIs and stimulus durations are interpreted in terms of masking; they fail to support an hypothesis of central intermittency.

107. Costa, L. D., Horwitz, M., & Vaughan, H. G., Jr. Effects of stimulus uncertainty and S-R compatibility on speed of digit coding. Journal of Experimental Psychology, 1966, 72 895-900.

One of 8 digit-digit coding tasks varying in 2 levels of stimulus uncertainty (Us) and 4 levels of S-R compatibility were administered to 8 different groups of 10 Ss each. Response speed was found to vary as a function of S-R compatibility and this effect increased as Us was raised from 1 to 3 bits. S-R compatibility effects in these tasks, in which sets of stimuli were identical and mode of motor response was held constant, were ascribed to the availability of logical S-R translation rules as a function of preexperimental experience.

108. Costa, L. D., Vaughan, H. G., Jr., & Gilden, L. Comparison of electromyographic and microswitch measures of auditory reaction time. Perceptual and Motor Skills, 1965, 20 771-772.

The RTs of 3 Ss to clicks at 10, 30 and 90 db above their individually measured thresholds were obtained. It was concluded that use of a microswitch for signalling motor response introduces a significant delay in comparison with an electromyographic measure. Large reliable individual differences in amount of switch lag were found. Switch lag decreased slightly as intensity was increased.

109. Craik, K. Theory of the human operator in control systems. British Journal of Psychology, 1947, 38, 56-61.

The human operator behaves basically as an intermittent correction servo (p. 56). The intermittent corrections consist of 'ballistic' movements (pp. 56-58). There are some counteracting processes tending to make controls seem continuous (pp. 58-59). Electrical models could fairly exactly simulate the human operator's behaviour in tracking (pp. 59-61).

110. Craik, K. Theory of the human operator in control systems. British Journal of Psychology, 1948, 38, 142-148.

I. Statement of the problem (p. 142). II. How the problem may be investigated (pp. 142-143). III. The first two steps in the chain of response (pp. 143-148): (a) The sense-organ (pp. 143-145); (b) The computing system (pp. 145-148). References (p. 148).

111. Creamer, L. R. Event uncertainty, psychological refractory period, and human data processing. Journal of Experimental Psychology, 1963, 66, 187-194.

An experiment was performed to (a) test the psychological refractory period (PRP) hypothesis of the human S as a 1-channel data processing system with an event uncertain-time certain stimulus series, and (b) determine the combined effect of time and event uncertainty. To test the PRP hypothesis, 5 groups of 12 Ss had 5 different time intervals between visual and audio stimuli (0, 100, 200, 400, and 800 msec.). The visual S-R sequence produced a delay in audio responses that was significant at 0-, 100-, and 200-msec. intervals. The human apparently responds as a 1-channel system when he processes event uncertain-time certain data. Another group of 12 Ss had the 5 interstimulus intervals with both time and event uncertainty. Their bisensory audio impairment was similar to the 5 time certain groups.

112. Cross, K., Noble, M., & Trumbo, D. On response-response compatibility. Human Factors, 1964, 6, 31-37.

This study was designed as a first step in the investigation of response-response compatibility effects, a compatibility phenomenon hypothesized by Fitts and his associates.

A two-hand cranking task was used in which S could, by manipulating two cranks, adjust a mechanical stylus to any one of one hundred points on a ten-by-ten matrix. The four possible combinations of clockwise and counterclockwise movements of the two cranks made up four response conditions. Three different stimulus types (codes) were used: digital, pictorial, and instructional. The stimuli, projected onto the rear side of a translucent screen located directly in front of S, indicated the point on the matrix to which S was to move the stylus. The target series used for each of the three stimulus types required the use of the four response conditions with equal frequency.

It was found that speed of both total adjustment and initial response was dependent upon the particular stimulus type used, but not dependent upon response conditions. In contrast, number of correct initial movements was dependent upon response conditions but not stimulus types. The latter was, however, a function of response sets rather than compatibility. No evidence of significant interaction was found.

The present findings fail to support the hypothesis of Fitts and his associates and time and motion principles which also, in effect, contend that S-R compatibility effects exist. Furthermore, the existence of response sets with no corresponding effect on the over-all efficiency of the system suggests that sets and compatibility are two different and not necessarily interacting phenomena.

113. Crossman, E. R. F. W. The information capacity of the human operator in symbolic and non-symbolic control processes. In Information Theory and the Human Operator. London: Ministry of Supply.

114. Crossman, E. R. F. W. Entropy and choice time: The effect of frequency unbalance on choice-response. Quarterly Journal of Experimental Psychology, 1953, 5, 41-51.

A human subject making a sequence of choice-responses is considered as a channel transmitting information. Earlier work suggests that the rate of transmission is limited, and so that response time is proportional to the "entropy" of the source of signals. Entropy is reduced by unbalance in the relative frequency of the possible signals according to the formula, sum (p log p). Unbalance should therefore reduce average response time. This prediction is tested in a card-sorting task. The subjects sorted playing-cards into classes in various ways; times taken were proportional to calculated entropy-per-card. Departures from the expected results occurred and were found to be due to differences in perceptual difficulty of discriminations. Some incidental results are mentioned.

115. Crossman, E. R. F. W. The measurement of discriminability. Quarterly Journal of Experimental Psychology, 1955, 7, 176-195.

A "confusion-function" was developed as a quantitative measure of "discriminability" and tested against observed times for visual and proprioceptive sorting tasks of various levels of "difficulty." "A method of extending its use to multi-choice and multi-dimensional signal-sets is outlined and experimental results concerning the former are presented."

116. Crossman, E. R. F. W. A theory of the acquisition of speed-skill. Ergonomics, 1959, 2, 153-166.

Recent researches are cited which suggest that the acquisition of manual speed-skill proceeds by a certain type of selective action. A formal theoretical model is developed, and its predictions compared with the experimental results. Certain complications of the theory, and conclusions from it are outlined, and the nature of the selective mechanism is discussed. Some implications for training are indicated.

117. Crossman, E. R. F. W. Reply to Dr. I. M. Hughes. Quarterly Journal of Experimental Psychology, 1964, 16, 181-183.

D

118. Dagle, E. F., Hill, M. D., & Smith, W. R. Response times in decision-making tasks. Air Force Cambridge Research Laboratories, Office of Aerospace Research. 1966.

The extent to which the output in semiautomated systems that utilize human operators is quantitatively and qualitatively accurate is an obvious function of system performance. When assigned to a logical function in a system, the human operator quite often affects total performance; however, little is known about his sources of error, particularly when his response time is concerned. This study presents experimental evidence which supports the hypotheses that human operators differ widely in the time they require to make decisions and it also provides data that show the degree of consistency or reliability of time measures taken at different times. By using data gathered in the manner outlined in this study, human operators could be matched to command or control systems according to the degree of speed and accuracy required by the particular system. Greater overall efficiency and a maximum output for any given system would be the result.

119. Dalrymple-Alford, E. C., & Aamiry, A. Speed of responding to mixed language signals. Psychonomic Science, 1967, 9, 535-536.

In two experiments Ss were presented with 2-word unilingual and mixed language signals which indicated which of six keys were to be pressed. While the speed with which the correct response was made was unaffected by whether the signal was linguistically mixed or not, the language of the first word appeared to be critical.

120. Davis, R. The limits of the "psychological refractory period." Quarterly Journal of Experimental Psychology, 1956, 8, 24-38.

Previous evidence on the psychological refractory period is shown to be inadequate on the crucial issue of whether delays, which cannot be overcome by practice, occur in responding to the second of two signals, when the interval between them is less than 0.5 seconds. For simple key pressing responses it is shown that when the interval between signals is less than the reaction time to the first signal, delays in the reaction time to the second signal occur in a predictable manner. When the interval is greater than the first reaction time, however, no such delays are found. Possible reasons for the discrepancy between these and earlier findings are suggested.

121. Davis, R. Central inhibition: Some refractory observations. (Two comments on the paper by Alick Elithorn and Catherine Lawrence) Quarterly Journal of Experimental Psychology, 1956, 8, 39-40.

"The arrival of a single stimulus raises the probability of its of its own response to the region of I-O, but at the same time it cuases the probability of the alternative situation to fall abruptly. Since this latter situation will arise sometime the probability that it will occur in the next time interval if it has not already occurred will increase with the passage of time until towards the end of the cycle this probability approaches unity." (Elithorn & Lawrence, 1955, p. 125).

The first probability here referred to is the probability of one or other of the stimulus-response patterns occurring first.

All entirely different probability is the probability of when in the time following the first, the second will occur. It does not follow that this probability is reduced to a relatively low value as a result of the first stimulus occurring.

There is no causal connection at all between the two probability measures. It is therefore a mistake to refer to some single probability level, changes in which are supposed to be reflected in changing excitability of the nervous system.

In seeking to explain the changes in the levels of probability by processes within the organism, if any one probability measure is taken, such as the changing probability of the second stimulus occurring as the time interval increases, then it might be possible to identify a state or process in the nervous system with the changing probability level.

If however, a different set of probabilities are measured, it is absurd to expect that some process in the system we are examining will reflect the change in probability value, when this change is a result of changing the circumstances about which the probability statement is made.

Thus to talk of "the process of inhibition or whatever physiological change accompanies sudden alternations in probability level" (and which takes a finite time) involves the confusion of invoking a process to account for a supposed change in the organism when the change in fact lies in the choice of what is to be measured.

The assumption that the state of preparedness of the subject for the second stimulus (and hence reduction of reaction time) keeps increasing with the passage of time after the first stimulus has occurred seems in conflict with previously established evidence, e.g. Mowrer (1940) and also with Elithorn and Lawrence's own results. The minimum second reaction times do not in fact occur at the longest interval. This discrepancy has already been discussed more fully above.

122. Davis, R. The human operator as a single channel information system. Quarterly Journal of Experimental Psychology, 1957, 9, 119-129.

A further experiment is reported on reaction times to stimuli separated by short intervals. On this occasion an auditory stimulus was followed by a visual stimulus. Results indicate that the pattern of delays at short intervals is the same as the pattern of delays when the stimuli are presented in one modality only. This suggests a model of the human operator functioning as a single channel through which information from both sense modalities has to pass before appropriate responses are organized. An attempt is also made to reconcile data with the known facts about the peripheral and central components of reaction time and the possibility that delays are the results of occupation of the channel for a central time plus a central refractory time is suggested.

123. Davis, R. The role of "attention" in the psychological refractory period. Quarterly Journal of Experimental Psychology, 1959, 11, 211-220.

A set of experiments is described in which two consecutive signals, separated by a variable time interval, were presented to the subjects. Manual reaction times to these signals were recorded and the delays in the reactions to the second of the two signals were compared in situations where the subject was required to respond to both signals and where he was not required to respond to the first signal.

The magnitude of the delays found at any particular interval were the same in both situations, and there was not much difference between cases where the two signals were in the same sense modality (visual) or in different modalities (visual, followed by auditory). These results confirm the suggestion of the writer in a previous paper that there may be a common analyzing and classifying system for auditory and visual information and also illustrate a new point. It is paying attention to a signal rather than performing any overt response to it which gives rise to delays in subsequent responses.

124. Davis, R. Choice reaction times and the theory of intermittency in human performance. Quarterly Journal of Experimental Psychology, 1962, 14, 157-166.

One visual signal, drawn from two equi-probable alternatives, was followed at a variable interval by a similar signal, also drawn from two equi-probable alternatives. The relationship between reaction time to the second signal and the interval between signals was studied under the following conditions: (1) Subjects were trained from the beginning to regard the first signal as irrelevant. (2) Subjects were asked to report on the nature of the first signal after they had responded to the second. The interval between signals was one of the five values, 50, 100, 150, 200, 250 millisec. In the regular interval situation the same interval was used over a block of 20 trials. In the random interval situation the values of the interval were randomly arranged, with equal frequency within each block of 20 trials.

The results showed: (1) In the random interval situation there was a definite disturbing of the first signal on the reaction time to the second, despite the fact that subjects were trained to disregard the first signal. However, the delays in reaction time were significant only at the shortest interval, 50 millisec. (2) In the regular interval situation this disturbing effect was not evident. (3) The additional requirement of having to report on the nature of the first signal produced no consistent increase in reaction time to the second signal. Some implications of these results for the conception of the human operator as a channel of limited capacity are discussed.

125. Davis, R. The combination of information from different sources. Quarterly Journal of Experimental Psychology, 1964, 16, 332-339.

In this experiment subjects were presented with visual information from two different sources and were required to combine it in order to make the correct response. The time interval between the two signals was varied in two different ways (a) regularly and (b) randomly. Reaction times were measured from the moment of occurrence of the second signal. By this means the time course of the decision procedure involved in combining the information from the two sources was analyzed.

Results indicate that subjects may deal with the situation in two ways (i) by means of a "perceptual" classification in which the individual elements are not analyzed separately, or (ii) by means of an "intellectual" classification in which each signal is analyzed sequentially. These two methods correspond to the experimental conditions of (a) regular intervals and (b) random intervals.

It is argued that when subjects use the latter strategy the results are consistent with the conception of the human operator as an intermittent analyzing system.

126. Davis, R. Expectancy and intermittency. Quarterly Journal of Experimental Psychology, 1965, 17, 75-78.

When a human subject responds to the second of two closely succeeding stimuli, his reaction time to the second stimulus tends to increase sharply as the interstimulus interval decreases. Controversy has centered on the issue of whether this increase is mainly due to the effects of the first stimulus in producing some kind of block in the central analysing systems or whether it is mainly due to the temporal uncertainty of the second signal, as determined by the distribution of interstimulus intervals used.

By substituting for the first stimulus a spontaneous response on the part of the subject and holding the distribution of interstimulus intervals constant, it is shown that the delays in responding to the succeeding signal are eliminated, even at intervals as short as 50 millisec. This is interpreted as evidence in support of the intermittency hypothesis and as a clear indication that the increase in reaction times normally observed is not a result of the distribution of interstimulus intervals.

127. Davis, R. A reply to Dr. Lawrence Karlin. Quarterly Journal of Experimental Psychology, 1965, 17, 352.

128. Davis, R. A reply to Dr. John Annett. Quarterly Journal of Experimental Psychology, 1966, 18, 180.

129. Davis, R. Intermittency and selective attention. Acta Psychologica, 1967, 27, 57-63.

Selective attention was investigated using a reaction time technique by presenting the subject with two signals separated by a variable time interval. One of the signals, the 'data' signal could take one of two values along each of two dimensions, colour and number. The other signal, the 'cue' signal indicated which of these dimensions was relevant for the subjects response. Two different conditions were examined. In the first the cue signal preceded the data signal by a variable interval; in the second the cue signal followed the data signal at a variable interval. By recording reaction times for a correct classification on a set of keys, it was shown that results for the first condition were consistent with sequential processing of the cue signal followed by the data signal. In the second condition a further source of intermittency appeared and this seemed to be due to the central systems becoming blocked by irrelevant information from the data signal.

130. Davis, R., & Green, F. A. Intersensory differences in the effect of warning signals on reaction time. Acta Psychologica, 1969, in press.

A visual signal with two equiprobable alternative values, calling for a manual choice response, was presented to the subject after a fairly long (5 secs) waiting period from the 'start' signal.

The effect of introducing a warning signal at a fixed interval between 0 and 500 ms prior to the visual signal to respond was examined. When the warning signal was presented in the auditory modality, it was found that simultaneous presentation of the auditory signal improved reaction times to the visual signal and that a further improvement developed as the interval was increased to 200 ms.

When the warning signal was presented visually no improvement in reaction times to the visual signal to respond was found until the interval reached 150 ms.

The results from the auditory warning condition may be accounted for by the difference in conduction latencies of simultaneously presented auditory and visual signals.

The results from the visual warning condition suggest that no use can be made of a warning signal entering by the same modality as the signal to respond until an interval of 100-150 ms has elapsed.

131. Davis, R., Moray, N., & Treisman, A. Imitative responses and the rate of gain of information. Quarterly Journal of Experimental Psychology, 1961, 13, 78-89.

A series of experiments is described on audio-verbal reaction times. In the first experiment the signals were letters or digits recorded on magnetic tape and presented through earphones. In the second experiment the signals were nonsense syllables drawn from vocabularies of different size. The subjects responded by repeating what they heard as soon as it was presented and reaction times were recorded. It is shown that the size of the group from which the signal is drawn has little effect on the reaction time to that signal. A distinction is drawn between situations in which the rate of gain of information may be expected to apply and situations in which it may not apply. It is suggested that many highly practiced skills fall into the latter category.

132. Davis, R., & Taylor, D. H. Classification of the basis of conditional cues. Quarterly Journal of Experimental Psychology, 1967, 19, 30-36.

Subjects were presented with signals from two sources, either simultaneously or successively. The signal from one source, the "cue" signal, provided information about the type of classification to be made; the signal from the other source provided the data for the classification. Reaction times were recorded from the moment of presentation of the second signal to the moment the subject pressed the appropriate response key. By varying the order of presentation and the time interval between cue and data signal, the time required for the subject to select the appropriate dimension of variation in the data signal was examined.

When the cue signal preceded the data signal, the results were consistent with consecutive sequential processing of the two signals. When the data signal preceded the cue signal a further source of delay was evident. It is suggested that this results from a type of intermittency in which processing of irrelevant aspects of the data signal holds up the analysis of the cue signal.

133. Deininger, R. L., & Fitts, P. M. Stimulus-response compatibility, information theory and perceptual motor performance. In H. Quastler (ed.) Information Theory in Psychology. Glencoe, Illinois: The Free Press.

134. Denison, D. M., & Ledwith, F. Complex reaction times at a simulated cabin altitude of 8,000 feet. RAF Institute of Aviation Medicine, Farnborough, Hants. 1964.

Eight subjects were tested on a task involving spatial transformations of information that was presented to them. Performance was compared under conditions equivalent to breathing air at ground level and at an altitude of 8,000 feet.

Reaction times were significantly slower at the 8,000 feet altitude, during the early learning of the skill.

135. Deupree, R. H., & Simon, J. R. Reaction time and movement time as a function of age, stimulus duration, and task difficulty. Ergonomics, 1963, 6, 403-411.

This study investigated the effects of age, stimulus duration, and task difficulty on reaction time and movement time. Subjects made a simple guided movement in response to the onset of a stimulus light. Two levels of task difficulty (simple and two-choice reaction) and three durations of the light (50 msec, response terminated, and movement terminated) were used to define six experimental conditions. Forty-eight subjects were used: 24 college sophomores with a median age of 20, and 24 elderly persons with a median age of 75.

Older subjects reacted 11 per cent slower and moved 38 per cent slower than young. Choice reactions were slower than simple reactions. Old subjects, but not young, moved faster in simple trials than in choice. The effect of stimulus duration was not significant. A predicted interaction of stimulus duration and age was also not supported. Proportionately greater slowing of reaction time for old subjects as difficulty increased was observed but failed to reach an acceptable level of significance.

136. Dillon, P. J. Stimulus versus response decisions as determinants of the relative frequency effect in disjunctive reaction-time performance. Journal of Experimental Psychology, 1966, 71, 321-330.

In a typical disjunctive reaction-time (DRT) task, one cannot separate the relative contributions of stimulus and response events to decisions underlying performance. In the present study, use of a conditional DRT technique permitted independent variation of stimulus and response frequencies. The effects of these variations on response latency and GSR were studied in 4 experiments, on a total of 96 Ss. An inverse relation between RT (and GSR) and frequency of the response alternatives, but not of the corresponding stimulus alternatives, was demonstrated. It is suggested that models of DPT performance should stress response-selection, rather than stimulus-identification, factors in decision processing.

137. Dimond, S. J. Storage of information about time. Perceptual and Motor Skills, 1965, 21, 261-262.

An experiment is described in which the detrimental effects of an auxiliary task on reaction time to periodically presented light stimuli were studied. RT stimuli were presented periodically to one group of Ss throughout the experiment and aperiodically to another. During the first half of the experiment both groups performed the RT task while simultaneously performing a key-pressing task, then both groups performed the RT task only. When performing the RT task only, the RTs of the 'periodic' group initially were of the same magnitude as those of the 'aperiodic' group but on subsequent periodic trials the RTs became significantly shorter. The results support the hypothesis that ability to gauge the time separating periodically occurring RT stimuli is impaired when S is required simultaneously to perform an auxiliary task.

138. Doherty, M. E. Information and discriminability as determinants of absolute judgment choice reaction time. Perception & Psychophysics, 1968, 3, 1-4.

Hick's law was generalized to the case of absolute judgment by measuring S's judgment time (JT) to unidimensionally varying, visual stimuli. The linear component of the regression of JT on transmitted information was highly significant, and was the only significant component, thus confirming Hick's law. Discriminability alone was found to be incapable of accounting for JT variance, although the results verified that, in the range manipulated, discriminability does affect performance. Further analyses revealed that stimulus-onset uncertainty does not, as Hick supposed, have the effect of adding one more state of the alternatives, and that Hick's law does not hold when applied to JTs to individual stimuli.

139. Donderi, D. C., & Zelnicker, D. Parallel processing in visual same-different decisions. Perception & Psychophysics, 1969, 5, 197-200.

Two of 13 geometrical shapes were exposed simultaneously to S who decided whether all shapes were the same or whether one was different from the rest. Correct different decisions were usually faster than correct same decisions, but latency was independent of the number of shapes presented. We conclude that input from all the shapes was simultaneously processed into either one or two shape categories, and that a decision-theory choice was made between "same" (one shape category) and "different" (two shape categories) independent of the total number of shapes. This parallel processing is thought to be a characteristic of codable stimuli. Some observed same-different latency reversals were probably caused by a shift in the same-different criterion on the continuum for one-vs two-category decisions.

140. Donders, F. C. Die schnelligkeit psychischer processe. Archive Fur Anatomie Physiologie, 1868, 657-681.

141. Drazin, D. H. Effects of foreperiod, foreperiod variability, and probability of stimulus occurrence on simple reaction time. Journal of Experimental Psychology, 1961, 62, 43-50.

In two parallel experiments, the foreperiod of a simple reaction task was varied at random within a rectangular frequency distribution. In a total of 14 conditions, the minimum foreperiod, range of foreperiods, and probability of stimulus occurrence were systematically varied.

The results indicate that the RT-foreperiod relationship is subject to a range effect: in all conditions where the range of foreperiods exceeded 0.5 sec., RT tended to decrease initially as a negatively accelerated function of the foreperiod. The detailed form of this relationship was found to depend upon the minimum foreperiod, the range of foreperiods, and the probability of stimulus occurrence. The scatter of RTs was greatest for short foreperiods and least for foreperiods of intermediate length.

Reaction time was also found to vary with the foreperiods of the preceding reaction and, to a less extent, the second preceding reaction: in either case, long RTs tended to follow reactions with short foreperiods and vice versa. The effect of immediate foreperiod was most marked following reactions with short foreperiods.

The experimental findings are interpreted as evidence in favor of the view that RT reflects S's state of readiness for the stimulus.

142. Dureman, I., Jonsson, B., & Wilen, B. Probability discordance and choice reaction time. I. Effects of discordant probability on choice reaction time during prolonged training. Scandinavian Journal of Psychology, 1963, 4, 33-36.

Successive development of disinhibitory action over long monotonous training periods was studied with choice RT stimuli possessing discordant properties related to their relative frequency and the direction of movement. The results indicate that stimuli with strong initial proactive interference on ensuing reaction to the critical probe-stimulus become, with prolonged training, the least interfering.

143. Dureman, I., & Wilen, B. Effects of interstimulus interval and predictability of event structure on serial reaction time. Scandinavian Journal of Psychology, 1963, 4, 135-138.

A mean interstimulus interval (ISI) of 10 sec. resulted in significantly shorter RTs to a single light stimulus than a 30 sec. average ISI. During a second work period the groups performing under each of the 2 ISI conditions were divided into 4 subgroups given 0, 25, 50, or 75% interspersion of an additional stimulus (sound). With short ISIs the condition of maximum predictability of event structure (light stimulus only) gave the shortest average RTs. With lessened predictability (increased proportion of the sound stimulus) there was a slight monotonous increase in RT. With long ISIs the same relationship was curvilinear, i.e. 25% interspersion of sound stimulus was most effective in preserving vigilance.

E

144. Edwards, W. Optimal strategies for seeking information: Models for statistics, choice reaction times, and human information processing. Journal of Mathematical Psychology, 1965, 2, 312-329.

Models for optional stopping in statistics are also normative models for tasks in which subjects may purchase risk-reducing information before making a decision. A Bayesian model for optional stopping for the two-hypothesis continuous case is developed; it takes explicit account of cost of information, values of the possible outcomes of the final decision, and prior probabilities of the hypotheses.

A nonparametric model for choice reaction times is derived. It makes strong predictions about times and errors; only one quantity in it is not directly observable.

A second example uses the model to design and predict results of a binomial information-purchase experiment.

145. Egeth, H. Parallel versus serial processes in multidimensional stimulus discrimination. Perception & Psychophysics, 1966, 1, 245-252.

Although considerable effort has been devoted to the description of processes underlying discriminations along single dimensions, there have been few attempts to determine whether or how these elementary processes are combined when discriminations requires the consideration of more than one stimulus dimension. In the present experiment, Ss were required to indicate whether two simultaneously presented multidimensional visual stimuli were identical or different. The response measure was reaction time, and Ss had a monetary incentive to respond both quickly and accurately. It was concluded that the most appropriate model for this task is one that assumes that dimensions are compared serially, and that the order in which dimensions are compared varies from trial-to-trial. Further, when a pair differs along several dimensions, Ss do not necessarily examine every dimension before initiating the response "Different."

146. Egeth, H., & Smith, E. E. On the nature of errors in a choice reaction task. Psychonomic Science, 1967, 8, 345-346.

The problem of dealing with incorrect responses in choice reaction times is discussed. In the present experiment, incorrect responses tended to yield functions that were very similar to the functions plotted from correct responses. However, they averaged about 50 msec. faster than the correct responses. These observations were taken to mean that errors are generated by essentially the same processes as are correct responses, but that these processes are not taken to completion in the former case.

147. Elithorn, A. Central intermittency: Some further observations. Quarterly Journal of Experimental Psychology, 1961, 13, 240-247.

When the human subject is asked to respond to two stimuli separated by a very short time interval the response to the second stimulus may be relatively delayed. The present experiment is designed to test the hypothesis that the elements of the delay atrributable to the sensory and motor components of the stimulus-response situation may be subserved by relatively independent neural mechanisms. The results obtained are compatible with this hypothesis and are briefly discussed.

148. Elithorn, A., & Barnett, T. J. Apparent individual differences in channel capacity. Acta Psychologica, 1967, 27, 75-83.

Two experiments are described which suggest that human subjects can respond independently to stimuli presented in opposite half fields. Individual differences in the ability to achieve such independent responses are related to personality variables and it is suggested that subjects who are able to process two stimuli achieve this by inhibiting the interhemisphere transfer of some part of the central organizing processes involved.

149. Elithorn, A., & Lawrence, C. Central inhibition-Some refractory observations. Quarterly Journal of Experimental Psychology, 1955, 7, 116-127.

The observation that response to the second of two stimuli is delayed if a response has to be made to the first has led to the development of a theory of a central refractory state during which incoming stimuli cannot be elaborated. In the experiment reported here the two stimulus-response situations have been made as independent as possible, and under these conditions it is shown that this theory cannot be maintained in its present form. The concept that the central integrating mechanism readily becomes blocked by any single stimulus is dismissed as nonproven and uneconomic. The present findings, however, confirm previous observations that some interference between the two situations may occur but indicate that his is not necessarily maximal immediately after the presentation of the first stimulus. It is tentatively suggested that the phenomena of central inhibition can be interpreted in terms of the interaction between the excitatory and inhibitory significance of the stimuli and the internal anticipatory set.

150. Elliott, D. N., & Lukaszewski, J. Reaction time as a function of induced muscular tension. Perceptual and Motor Skills, 1961, 13, 183-189.

RTs were determined, under both simple RT and disjunctive RT conditions, at two levels of spring tension of the reaction key. For simple RTs, springloading the reaction key resulted in shorter RTs. For disjunctive RTs, the effect was not significant or generally evident. It was suggested that the decrease in simple RTs was due to a reduction in the "competition" of the equally active neural pathways leading to the antagonistic sets of muscles involved in the response. The lack of a significant decrease for the disjunctive RTs was judged to be due to an inappropriate level of spring tension.

151. Elliott, R. Simple visual and simple auditory reaction time: A comparison. Psychonomic Science, 1968, 10, 335-336.

In two experiments the classically reported difference of about 40 msec between simple RTs to high intensity tone and light was reproduced using 1^{o} and 3^{o} targets, but was reduced to 24 msec by illuminating virtually the whole retinal surface. In a third experiment, the indicated relations between target size and RT were repeated.

152. Emerson, P. L. Foreperiod sequence effects in the RT-foreperiod relation. Dissertation Abstracts, 1966, 27, 311-312.

Three experiments were conducted to investigate the effects of the past sequence of foreperiods on the RT-foreperiod relation. In Experiment I, rectangular distributions of log-foreperiod were used. Four combinations of two levels of the mean and two levels of the SD of the distribution were used, and an analysis of variance indicated that the RT-relative-foreperiod relation changes when the mean of the distribution changes. A nonlinear serial regression model based upon the adaptation-level concept was also applied, and both analyses indicated that minimum reaction time falls above the predicted adaptation level and above the mean of the distribution of foreperiods. The sequential analysis usually accounted for more variance than the means of reaction time for different foreperiods.

In Experiment II, bimodal distributions of foreperiods were used, and as the variance of the distribution was increased, the tendency toward two local minima of average reaction time also increased. The minima were at foreperiods longer than those presented most frequently.

In Experiment III, uncertainty as to the eventual occurrence of the reaction signal was introduced by including different relative frequencies of dummy trials in which the trial ended without the presentation of the reaction signal. With the introduction of uncertainty, the minimum reaction time moved down toward the mean of the distribution of foreperiods.

As the adaptation- level model did not appear appropriate, other possible formulations were considered, and the simplest prospective sequential formulation appeared to be one in which readiness is expressed as a weighted moving average of the current estimate of the foreperiod distribution, where the weight function is an exponential or a low-order gamma distribution whose SD is adjusted optimally on each trial. A less simple but more theoretically significant conceptualization in which readiness was interpreted as arousal, was also considered.

153. Estes, W. K., & Wessel, D. L. Reaction time in relation to display size and correctness of response in forced-choice visual signal detection. Perception & Psychophysics, 1966, 1, 369-373.

Response times were recorded in a two-alternative, forced choice visual detection situation. Stimulus displays, presented tachistoscopically, were randomly selected consonant letters distributed in random subsets of cells of a matrix. Display sizes in Experiment 1 were 8, 12, and 16 letters; in Experiment 2 - 1, 4, and 8 letters; on each trial S operated a key to indicate which member of a predesignated pair of letters (signal elements) was present in a given display. Correct response times, on the average, increased uniformly with display size. Incorrect response times were uniformly greater than correct response times and, except for a reduction in the case of one element displays, were constant over display size. These relationships appear to require a modification of one assumption in the earlier proposed serial processing model for tachistoscopic perception.

F

154. Fairbank, B. A., Jr., & Capehart, J. Decision speed for the choosing of the larger or the smaller of two digits. Psychonomic Science, 1969, 14, 148.

A recent published report suggests that numbers may be processed internally as analog magnitudes when Ss are required to select the larger of two digits. If this is the case then it is suggested that Ss should be able to select larger digits more quickly than smaller digits. Experimental investigation confirms that the choosing of larger digits is faster than the choosing of smaller digits.

155. Falmagne, J. C. Le conflit rapidite - precision dans les T. R. de choix. [The speed-precision conflict in discriminative reaction times.] Bulletin du Centre d'Etudes et Recherches Psychotechniques, 1963, 12, 161-186.

This paper develops a probability model for the mechanism of errors in a situation of choice reaction times. The model is based on the notion of selective preparation and extends a previous model on response latencies. The predictions of the model are compared with experimental results.

156. Falmagne, J. C. Stochastic models for choice reaction time with applications to experimental results. Journal of Mathematical Psychology, 1965, 2, 77- 124.

Choice reaction times are analyzed on the basis of a simple model in which RT's are drawn at random from one of two ideal distributions. The two distributions correspond to different states of preparation. Loosely speaking, the subject learns to expect certain stimuli and not others. Accordingly he draws his response from one or the other of two ideal distributions depending on whether or not he is prepared for the stimulus that is presented. The probability of this choice is determined by the sequence of stimuli prior to the response. The proposed model specifies a statistical learning process connecting the preparatory states to stimuli, and a sampling scheme that generates the RT distributions from the preparatory states. The model attempts to account for the relation between RT and stimulus probability, as well as for a variety of sequential effects found in reaction times. An experiment on choice RT is described. The model is applied in detail, parameters are estimated, and the outcome is subjected to critical scrutiny.

157. Falmagne, J. C., & Theios, J. On attention and memory in reaction time experiments. Acta Psychologica, 1969, 30, 316-323.

158. Favreau, O. Proactive decremental effects on response speed in a continuous DRT task. Psychonomic Science, 1964, 1, 319-320.

Thirty Ss performed a 324-trial, subject-paced, two-signal, frequency-imbalanced, disjunctive reaction time task. Responses on trials following the occurrence of the infrequent signal yielded longer RTs than responses on other trials. This effect is attributed to novelty produced "startle," and is different from series effects previously reported.

159. Fehrer, E., & Biederman, I. A comparison of reaction time and verbal report in the detection of masked stimuli. Journal of Experimental Psychology, 1962, 64, 126-130.

In the present study, we have compared the accuracy of two measures, reaction time and verbal report, in the detection of an event subjected to retroactive masking. A 5-msec darkening of an otherwise steadily illuminated area was followed, after delays varying from 0 to 75 msec, by a 100-msec illumination of two adjoining areas. At certain critical delays at which verbal detection of the test stimulus was little above chance accuracy, RT to the darkening of the test stimulus was not affected by the delayed presentation of the masking lights. Compared with verbal report, therefore, RT provided a far more accurate measure of the presence of the masked stimulus event.

160. Fehrer, E., & Raab, D. Reaction time to stimuli masked by metacontrast. Journal of Experimental Psychology, 1962, 63, 143-147.

This study was designed to determine whether metacontrast suppression of a light flash affects RT to the flash. Masking of a square target was achieved by subsequent flashing of two adjacent squares. Stimulus onset asynchronies were studied over a range from 0 to 75 msec. Phenomenal suppression of the first flash varied from none (0 asynchrony) to maximum (75 msec asynchrony).

161. Fitts, P. M. The information capacity of the human motor system in controlling the amplitude of movement. Journal of Experimental Psychology, 1954, 47, 381-390.

The present paper attempts to relate the traditional Weber function (variability of a response as a function of its amplitude) to the parallel phenomena of variability as a function of response duration, using certain concepts of information theory.

An index of the difficulty of a movement is proposed on the assumption that the average amplitude, the average duration, and the amplitude variability of successive movements are related in a manner suggested by information theory. The basic rationale is that the minimum amount of information required to produce a movement having a particular average amplitude plus or minus a specified tolerance (variable error) is proportional to the logarithm of the ratio of the tolerance to the possible amplitude range. The specification of the possible amplitude range is arbitrary and has been set at twice the average amplitude. The average rate of information generated by a series of movements is the average information per movement divided by the time per movement.

Three experiments are reported which were designed to test the following hypothesis: If the amplitude and tolerance limits of a task are fixed and the S is instructed to work at his maximum rate, then the average duration of responses will be directly proportional to the minimum average amount of information per response (i.e., the degree of behavior organization) demanded by the task conditions. The conditions studied covered the range from 1 to 10 bits/response.

The results indicate that rate of performance in a given type of task is approximately constant over a considerable range of movement amplitudes and tolerance limits, but falls off outside this optimum range. The level of optimum performance was found to vary slightly among the three tasks in the range between about 10 to 12 bits/sec. The consistency of these results supports the basic thesis that the performance capacity of the human motor system plus its associated visual and proprioceptive feedback mechanisms, when measured in information units, is relatively constant over a considerable range of task conditions. This thesis offers a plausible way of accounting for what otherwise appear to be conflicting data on the durations of different types of movements.

The author feels that the fixed information-handling capacity of the motor system probably reflects a fixed capacity of central mechanisms for monitoring the results of the ongoing motor activity while at the same time maintaining the necessary degree of organization with respect to the magnitude and timing of successive movements.

162. Fitts, P. M. Human information handling in speeded tasks. Poughkeepsie, New York: IBM Research Report. RC-109, 1959.

Many factors combine to limit the rate at which man can respond to a sequence of stimuli or a continuous signal. He has limited ability for identifying signals and differentiating responses. His motor and verbal response mechanisms can only generate response sequences at some limited rate, and he has limited ability to hold information in running memory (or buffer storage). Even more important in many tasks, however, is the time required for central information handling processes. The present paper reviews the data regarding man's information handling rates, interprets these findings from the viewpoint of information transformation or translation processes, and offers a series of hypotheses for the prediction of performance levels from a knowledge of stimulus and response coding. Some speculations are also offered regarding the possible mechanisms that may be involved in information processing.

163. Fitts, P. M. Perceptual-motor skill learning. In A. W. Melton (ed.), Categories of Human Learning. New York: Academic Press, 1964.

In this chapter I have placed particular emphasis upon (a) the importance of research on spatial-temporal patterns of behavior, including patterns lasting for only a second or less, and (b) the importance of stimulus coherence as the objective characteristic of tasks and sequences which appears to be of widest importance and of most theoretical interest.

The theoretical idea which I would re-emphasize is that of hierarchical processes in a complex skill is by analogy with the executive routines written into computer programs. The corresponding view of lower level processes is by analogy to the loops and subroutines of such programs. The theoretical view of skilled performance here proposed minimizes the role of motor behavior per se, and thus removes the principal basis for the commonly made distinction between verbal and motor processes. Instead it places major emphasis on the intrinsic coherence of stimulus and response sequences and the cognitive or higher-level processes that govern behavior sequence, and suggests that important aspects of response sequences include such factors as timing, the interrelations of speed, accuracy, and uncertainty, and the limitations imposed by capacities for discrimination and memory.

The crucial point in developing a general theory of skilled performance, and in support of the view that verbal and motor processes are highly similar, is the conclusion that skilled performance is dependent on discrete or quantized processes. Thus the study of discrete perceptual-motor responses, including the study of reaction time, movement time, and response accuracy (errors), can be viewed as contributing to an understanding of serial and continuous communication and controlled skills on the one hand, and to an understanding of the organization of thinking, decision making, and verbal behavior on the other hand.

164. Fitts, P. M. Cognitive aspects of information processing: III. Set for speed versus accuracy. Journal of Experimental Psychology, 1966, 71, 849-857.

This study examines the capacity of Os to adapt to changes in the relative emphasis on speed vs. accuracy of responses. Three matched groups of 6 Os each were trained for 3 days in a choice reaction-time (RT) task, with feedback indicating both speed and accuracy. Emphasis on speed decreased mean RT but increased errors. A control group, working without an exact payoff or immediate feedback, showed somewhat greater within- and between-S variability than did either the speed or accuracy groups and was at an intermediate level on all performance measures. Similar distributions of RTs were found for correct responses and for errors as was predicted by a sequential sampling and decision model choice RT. RT distributions for all Os were approximately normal under a set for speed, but under accuracy instructions some Os gave highly skewed distributions.

165. Fitts, P. M., & Biederman, I. S-R compatibility and information reduction. Journal of Experimental Psychology, 1965, 69, 408-412.

S-R compatibility effects were examined in 4 information-processing tasks (1-bit information conserving, 2-bit conserving, 2 to 1 bit filtering, and 2 to 1 bit condensing) in combination with 2 sets of responses (2 or 4 fingers of 1 hand only vs. 1 or 2 fingers of both hands). Eight different groups of 10 Ss each were used, 1 under each condition, and tested for 2 sessions. One-bit conserving and 2 to 1 bit filtering were accomplished about equally well, under both response codes. The other 4 tasks involved significantly more time and errors. When a compatible (2-hand) response code was used, 2-bit information conserving was more efficient than 2 to 1 bit information condensing, notwithstanding the fact that the former involved twice as many alternative responses; these relations were reversed when a less compatible (1-hand) response code was used. These results indicate the importance of response coding in interpreting studies of different information-handling processes.

166. Fitts, P. M., & Deininger, R. L. S-R compatibility: Correspondence among paired elements within stimulus and response codes. Journal of Experimental Psychology, 1954, 48, 483-492.

An experiment was conducted to test the hypothesis that S-R compatibility is maximum when the pairings of stimulus and response elements in the formation of an S-R ensemble insure maximum agreement with population stereotypes. The experiment permitted a further test of the previously examined hypothesis that maximum S-R compatibility requires correspondence of stimulus sets and response sets in respect to the dimensions along which stimulus and response categories are selected, and also an evaluation of the interaction of the choice of stimulus sets with the method of S-R pairing.

Compatibility effects are conceived as arising from an intervening information transformation process which is indicated by the statistical interactions of stimulus sets, response sets, and S-R mating procedures. The hypothesis was tested by analyzing the reaction times and errors of Ss in a series of different experimental situations. These results indicate that compatibility effects in perceptual-motor tasks are relatively large in comparison with effects produced by short-term learning or by changes in the number of alternatives (amount of information) relevant to each successive choice. The effects also appear to be relatively permanent.

Implications of the concept of compatibility for studies of transfer of training and individual differences are discussed.

167. Fitts, P. M., & Peterson, J. R. Information capacity of discrete motor responses. Journal of Experimental Psychology, 1964, 67, 103-112.

The effects of response amplitude and terminal accuracy on 2-choice reaction time (RT) and on movement time (MT) were studied. Both the required amplitude (A) of a movement, and the width (W) of the target that S was required to hit, had a large and systematic effect on MT, whereas they had a relatively small effect on RT. Defining an index of movement difficulty as $ID = \log_2 2A/W$, the correlation between ID and MT was found to be above .99 over the ID range from 2.6 to 7.6 bits per response. Thus the times for discrete movements follow the same type of law as was found earlier to hold for serial responses. The relative independence of RT and MT is interpreted as pointing to the serial and independent nature of perceptual and motor processes.

168. Fitts, P. M., Peterson, J. R., & Wolpe, G. Cognitive aspects of information processing: II Adjustments to stimulus redundancy. Journal of Experimental Psychology, 1963, 65, 423-432.

Three experiments are reported in which relative stimulus frequencies were varied in 9 choice tasks. The tasks involved naming numbers and pointing to lights. It was found that as redundancy increased average RTs to the frequent stimulus component decreased whereas RTs to less frequent components increased, the differences being a linear function of redundancy. These effects were greater for the less compatible (vocal) task. Ss used the frequent response more often and the infrequent response less often than appropriate in responding to redundant sequences. These results are in agreement with predictions from a stimulus sampling and sequential decision model in which it is assumed that RTs and errors are a function of prior probabilities and the payoff matrix for correct and wrong, slow and fast responses, as well as a function of stimulus discriminability.

169. Fitts, P. M., & Posner, M. I. Human performance. Belmont, California: Brooks/Cole, 1967.

170. Fitts, P. M., & Radford, B. K. Information capacity of discrete motor responses under different cognitive sets. Journal of Experimental Psychology, 1966, 71, 475-482.

Previous findings on the interrelations of speed, amplitude, and accuracy of movements support the conclusion that the human motor system has a relatively constant information capacity over rather wide limits. The experiments here reported examine extensions of this conclusion by comparing (a) movements that are initiated at S's convenience vs. movements following a 2 choice reaction time, and (b) the effects of variations in instructions and payoffs emphasizing speed vs. accuracy. It is concluded that (a) there is little or no benefit in spending additional time in preparation for the initiation of a skilled movement; only an increase in the time actually spent in executing a movement is of value in increasing accuracy, and (b) within limits, the information capacity of the human motor system is relatively invariant under changing cognitive sets for speed vs. accuracy.

171. Fitts, P. M., & Seeger, C. M. S-R compatibility: Spatial characteristics of stimulus and response codes. Journal of Experimental Psychology, 1953, 46, 199-210.

Experiment I was planned to test the hypothesis that information transfer in a perceptual-motor task is in large measure a function of the matching of sets of stimuli and sets of responses. Nine S-R ensembles, involving variations of the spatial patterns of stimuli and responses, were studied in an eight-choice situation, using groups of matched Ss.

The results, analyzed in terms of reaction time, errors, and information lost, support the hypothesis. They indicate that it is not permissible to conclude that any particular set of stimuli, or set of responses, will provide a high rate of information transfer; it is the ensemble of S-R combinations that must be considered.

Experiment II was planned to test the permanence of three selected S-R compatibility effects. Five Ss were trained for 32 days to make a particular set of responses to each of three sets of stimuli. Differences in reaction time, movement time, and frequency of errors in responding to the three sets of stimuli persisted over the 32 days.

The results are interpreted in terms of probability learning and the necessity for (hypothetical) information transformation or re-encoding steps. It appears that it is very difficult for Ss to learn to deal effectively with the information (uncertainties) characteristic of a specific situation, if these uncertainties are different from the more general set of probabilities which have been learned in similar life situations.

172. Fitts, P. M., & Switzer, G. Cognitive aspects of information processing. Journal of Experimental Psychology, 1962, 63, 321-329.

The investigation concerned S's ability to reduce his reaction time (RT) on the basis of knowledge that only a small subset of a larger, familiar alphabet would occur as stimuli in a particular experiment. It was predicted that Ss could make effective use of this knowledge only when the smaller subset itself constituted a highly familiar group. English letters and numerals were used as stimuli and familiar as well as unfamiliar subsets were enployed; the response was to vocalize the familiar name of the stimulus.

The results of three experiments were in agreement with the predictions. RTs were faster for small, familiar subsets (such as 1, 2; a, b, c); RTs for small, unfamiliar subsets (such as 2, 7; 4, 7; e, b, p) were about as slow as for the larger familiar sets of which they normally were a part. In no instance, however, was the absolute reduction in RT resulting from a decrease in number of alternatives very large for English language alphabets. It therefore appears that large differences in RT may result from changes in number of alternatives only when tasks are low in S-R compatibility, such as tasks using novel S-R codes or requiring novel information transformations.

These results support the view that information-handling rate is in part a function of cognitive sets which reflect the preparation which S makes, in advance, for responding to any one of a group of stimuli. Some characteristics of these cognitive sets are discussed, and the notion is related to recent theories of choice behavior.

173. Fleishman, E. A., & Hempel, W. E. Relation between abilities and improvement with practice in a visual discrimination reaction task. Journal of Experimental Psychology, 1955, 49, 301-312.

A practice task together with a number of reference tests was administered. A factor analysis of scores obtained at different stages of proficiency on the practice task together with scores on the reference tests was carried out. The results confirmed earlier findings with a different psychomotor practice task that considerable but systematic changes in factor structure occur as a function of practice. However, in contrast to the previous study, the present task did not become progressively less complex (in terms of the number of factors measured) as practice was continued. As before, there was an increase in the contribution of a factor common only to the practice task, but this increase was not as marked as with the previous task.

174. Flores, I. The effect of organization upon complex reaction time. Journal of Psychology, 1956, 41, 301-313.

In this experiment, two fields, each of 10 squares numbered 1 through 10 were presented to the subjects. The subject responded by pressing a square in the response field corresponding to the one in the stimulus field which had become lit. Four runs of 25 stimuli were presented to each of 10 subjects for each of four types of organizations. These latter were: linearly organized stimulus and response fields; linearly organized stimulus and randomly organized response fields; randomly organized stimulus and linearly organized response fields; randomly organized stimulus and response fields. The experiment was performed automatically so that a constant period of three seconds occurred between the subject's response and the subsequent presentation.

Analysis of variance as applied to the results of the experiment showed differences in treatments significant to the 0.05 per cent level, except one significant at the 1 per cent level.

Learning was shown to occur and when its effects were eliminated the difference in treatments was still significant at the 0.05 level, except one significant at the 2.5 per cent level. This was when learning had proceeded to its physiological limit.

It was further demonstrated that a greater reduction in reaction time to a complex situation with randomly organized fields was achieved by organization of both fields that the sum of the reductions achieved when either field was separately organized.

175. Foley, P. J. The foreperiod and simple reaction time. Canadian Journal of Psychology, 1959, 13, 20-22.

An experiment was undertaken to answer the following questions. (1) In obtaining the shortest reaction time, is the duration of the ready signal itself related to the duration of the foreperiod? (2) Does the effective foreperiod start with the onset of the ready signal, or with its cessation? It was concluded that relative duration has no effect, but that the effective foreperiod starts with the onset of the ready signal. The relevance of these conclusions to the discrepancies in optimum foreperiod length reported in the literature is discussed.

176. Foley, P. J., & Dewis, E. V. T. Pacing rate and warning signal in serial simple reaction time. Canadian Journal of Psychology, 1960, 14, 7-12.

A serial reaction time experiment was undertaken to answer the following questions: (1) Is the foreperiod effect a true foreperiod effect, or is it a product of the different pacing rates used; (2) Is a serial reaction time task where the preceding stimulus serves as the warning signal for the next response different from one where a separate warning signal is given?

It was concluded that: (1) the foreperiod effect is a true foreperiod effect? (2) the task with no warning signal does not differ from the task with a warning signal.

177. Foley, P. J.,& Humphries, M. Blocking in serial simple reaction tasks. Canadian Journal of Psychology, 1962, 16, 128-137.

Two experiments were carried out using simple serial reaction tasks in the visual and auditory modalities, in an attempt to elucidate the underlying principles involved in blocking. Previous tasks involved choice on the part of Ss, and a consequent complex of criteria including error scores.

Blocks, defined by the present authors as response times which exceed the mean response time by 3.29 times the standard deviation, occur in simple serial reaction tasks for all Ss.

There is no evidence of any correlation between blocking and simple fatigue or inhibition. Neither is there evidence of periodicity.

The present results do not support any previous attempts to account for blocking, nor do they suggest an easy solution to the problem.

178. Forrin, B., & Morin, R. E. Effects of contextual associations upon selective reaction time in a numeral-naming task. Journal of Experimental Psychology, 1966, 71, 40-46.

The increase in reaction time (RT) with size of the stimulus set for selective response tasks involving the naming of 1 of n equiprobable numerals has been ascribed to variation in attributes of the stimulus sequence--reduced probabiliby of signal presentation, increased mean intersignal interval, and heightened temporal uncertainty of signal occurrence.

The present study provided an independent assessment of the effect upon selective RT of a 4th factor commonly confounded with the preceding 3: the presence of incompatible S-R associations in serial context with numeral-numeral pairs. The data indicate that requiring Ss to remain silent to a given subset of numerals, or to respond with the single designation "No" to members of that subset, produced longer reaction latencies to numerals to be named than would be predicted from properties of the stimulus sequence alone. An interpretation in terms of generalized response inhibition and response competition is examined.

179. Forrin, B., & Morin, R. E. Effects of context on reaction time to optimally coded signals. Acta Psychologica, 1967, 27, 188-196.

It has frequently been observed that the time required to name a given numeral is relatively unaffected by the number of additional numerals in the stimulus set. In contrast, the results of the present study demonstrated that the latencies of numeral-naming reactions were significantly increased by the presence, in serial context, of geometric symbols coded arbitrarily. To account for the rise in RT to numerals, a two-stage identification process was tentatively propsed: S first recognizes the class of the stimulus displayed (numeral or symbol) and, subsequently, identifies the specific element withing that class. Predictions derived from this conjecture received only partial support from the data.

180. Forrin, B., & Morin, R. E. Recognition times for items in short-and long-term memory. Acta Psychologica, 1969, in press.

Reaction times were measured in a classification task which imposed a concurrent load on short- and long-term memory. Ss were required to identify the class membership ("positive" or "negative") of two types of test stimuli. For long-term items, the class assignment remained constant throughout the course of the experiment? for short-term items, it was specified anew on each trial. The results offered no support for the view that s accomplishes the classification task by a search through a unitary short-term or active memory to which the contents of long-term memory have been transferred. To the contrary, they tenede to favor the conjecture that the two sets of items (long and short-term) are maintained in memory stores sufficiently distinct that one may be operated upon independently of the other.

181. Foss, D. J., & Lynch, R. H. Decision processes during sentence comprehension: Effects of surface structure on decision times. Perception& Psychophysics, 1969, 5, 145-148.

Sentence comprehension is considered to be a set of decisions concerning the identification of entities at the various linguistic "levels." Such decisions utilize overlapping fixed capacity psychological mechanisms. To the extent that one decision is difficult, others should take longer. This framework received support in two studies in which Ss' reaction times (RT) to the presence of a phoneme in a sentence were measured. When surface structure syntax was difficult, as in self-embedded sentences, RT was longer (given that S comprehended the sentence) than when surface structure syntax was relatively easy. Additionally, the presence in surface structure of a putative cue for underlying structure did not affect RT, though comprehension was significantly inferior.

182. Fraisse, P. La periode refractoire psychologique. [The psychological refractory period.] Anne Psychologie, 1957, 57, 315-328.

The relative prolongation of reaction to a second stimulation following close on a first one depends on perceptive and motor phenomena of peripheral origin. It occurs as well without response to a first stimulation. If the interval between first and second stimulation is known to the S, the reaction time is shortened.

183. Fraisse, P. Recognition time measured by verbal reaction to figures and words. Perceptual and Motor Skills, 1960, 11, 204.

Five Ss were required to recognise as quickly as possible four words (square, triangle, hexagon, octagon) and the four corresponding figures. Ss were acquainted with the eight stimuli, for the present experiment was preceded by one in which tachistoscopic perceptual thresholds were obtained. The stimuli were presented in random order for an unlimited time and the whole list was shown five times. Verbal reaction time was recorded by means of a vocal key. S's median for each stimulus was calculated, and then the mean of medians for words and figures. Results are given in .01 sec.

Analysis of the variance gives an F between Subjects of 25.15 (p=.01); Between Forms and words: 25.56 (p=.01); between triangle and square on one hand, and hexagon and octagon on the other: F=9.68 (p=.01). Time for naming a word was shorter than time for naming a shape, as Ligon (1932) had found for colors. It seems that there is, indeed, a supplementary coding by S of the concrete sign and it is necessary for S to make the transition from the sign to the word. Also, time for reading words of varying frequency and length (cf. square and hexagon) does not differ eithing the limits of this experiment. On the contrary, time for naming figures depends on thier complexity and their degree of differentiation (cf. the hexagon and octagon).

184. Fraisse, P. Relations entre le seuil de reconnaissance perceptive et le temps de reaction verbale. [Relations between the perceptual recognition threshold and verbal reaction time.] Psychologie Francaise, 1964, 9, 77-85.

There is a notable correlation between perceptual recognition threshold and verbal reaction time depending on the material (verbal or non-verbal) used.

This correlation shows a functional connection between these two aspects of the perceptual process, as the results show that the variables such as uncertainty or discriminability have parallel effects on perceptual recognition threshold and verbal reaction time.

185. Fraisse, P. Latency of different verbal responses to the same stimulus. Quarterly Journal of Experimental Psychology, 1967, 19, 353-355.

A response of reading (letter O) or of naming (circle) can be given to the same sign O. The verbal reaction time is higher when naming than when reading (difference 100 millisec.). This fact verifies that naming is a longer process than reading, the difficulty of perceiving the stimulus being equal.

The response "zero" which may be given to the same sign is nearer to the reading-response time than the naming-response. These facts can be explained if we say that uncertainty for coding concrete signs is greater than for alphabetical or numerical signs.

186. Fraisse, P. Motor and verbal reaction times to words and drawings. Psychonomic Science, 1968, 12, 235-236.

Verbal reaction time to drawings is always a little longer than verbal reaction time to words. In previous experiments this finding had been interpreted in terms of the greater uncertainty when naming a drawing than when reading a word. In the present experiment, it is shown that the discriminability of the two categories of stimuli cannot explain the differences in VRT since the motor reaction time and the recognition threshold are a little higher for words than for drawings.

187. Fraisse, P., Lanati, L., Regnier, J., & Wahl, M. Le tempts de reaction verbale: II. Responses specifiques et categorielles. [Verbal reaction time: Specific and categorical responses.] Annee Psychologique, 1965, 65, 27-32.

Ss were shown either the picture or name of 16 stimuli in 4 categories (flowers, animals, fruit, objects) and asked to respond as quickly as possible by naming or reading the name, or by stating its category. Verbal reaction time was always greater for categorical than for specific response. Difference in time was more striking for word than for picture stimulus.

188. Fraisse, P., & Piaget, J. Traite de psychologie experimentale: II Sensation et motricite [Treatise on experimental psychology: II Sensation and motor activity.] Paris: Press Universitaires de France, 1963.

H. Pieron gives a critical survey of the development of objective psychophysics and trends in subjective psychophysics. R. Chocholle deals with delays accumulating on all levels of functioning and presents techniques, results of experiments, and factors affecting reaction time. J. Leplat attempts to convey the diversity of views on sensory-motor connections and the emerging connections with psychology of work, theory of communication, and feed-back.

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189. Gatewood, E. L. Individual differences in finger reactions. Psychological Monographs, 1920, (Whole No. 126).

Briefly stated, the results of these experiments, which include some 70,000 reactions, under as uniform conditions as possible, justify the following conclusions:

1. There are measurable differences between the reactions of the several fingers, first on the basis of speed and second on the basis of accuracy.

2. The fingers of the right hand (at least in right-handed people) are on the average faster than the fingers of the left hand. The fingers of the right hand also excel in accuracy, but the differences in this respect are slight.

3. The finger with which a given finger reacts effects the speed of the given finger. In other words, finger 2, for example, reacts faster when the other finger of the combination is finger 7, than with any other finger. The effect of the combination upon the reaction time of the given finger is relatively uniform for the different subjects. Anatomatical structure and common developments due to habits of life are probable explanations for this similarity.

4. Two-finger reactions, at least where there is double stimulation and double reaction, are faster than single-finger reactions, and are also more accurate.

5. Two-hand combinations, i.e. those in which one finger is on the left hand and the other on the right, give faster reaction times than those combination in which both fingers are on the same hand. Of the twenty combinations, (out of the whole forty-five) that are the fastest in reaction time, 68 percent of them are two-hand combinations, 26 percent are right-handed combinations, while only 6 percent are left-hand combinations. In opposition to the assertion of Fere, these results justify the conclusion that two-hand reaction are the fastest, right-hand reaction second and left-hand reactions slowest of all, when double reactions are concerned.

6. Practise increases the speed and accuracy of all the fingers. It tends to increase some more than others, thus lessening the difference between fingers. However, after a second performance of the entire forty-five combinations, finger differences are still found, similar to those originally present.

7. Individuals differ, both in speed and accuracy. There are some individuals who, with unlimited practise will not attain the speed and accuracy which some others show at the initial trial. With very few exceptions, subjects agree that greatest speed is obtained when using two hands, i.e., one finger on each and the lowest speed is obtained when both fingers used are members of the left hand. The same is true for accuracy. Trained subjects, those having a considerable amount of piano or other similar practise, show less difference between fingers than do the untrained subjects.

190. Geblewiczowa, M. Influence of the number of warning signals and of the intervals between them on simple reaction time. Acta Psychologica, 1963, 21, 40-48.

The purpose of this paper is to present the results of investigations of the relationship between reaction time and the variables connected with warning signals.

Chronologically the first problem refers to the relationship between reaction time and number of warning signals used in the series of measurements. The investigations were carried out with four groups of subjects: 23 male students, 21 female students, 23 schoolboys and 21 schoolgirls.

Reaction time with auditory stimulus was measured by means of a d'Arsonal chronometer. Three experiments were carried out:

Experiment A - each of ten trials preceded by two warning signals.

Experiment B - each of ten trials preceded by one warning signal.

Experiment C - no warning signal used.

It has been found that the shortest reaction times appear when in investigations two warning signals are used, whereas longer reaction times are obtained with one warning signal, and the longest when there is no warning signal.

The second problem concerns the relationship between reaction time and intervals between two warning signals. Twenty male students and 20 female students were examined.

The results obtained permitted us to establish the following data: the shorter intervals between two warning signals, the shorter the reaction times. In this work the shortest reaction times were obtained at the intervals of 0.5 sec., the longest at the intervals of 2.5 sec., and the medial reaction times at the intervals of 1.5 sec.

191. Gescheider, G. A., Wright, J. H., & Evans, M. B. Reaction time in the detection of vibrotactile signals. Journal of Experimental Psychology, 1968, 77, 501-504.

3 Ss made judgements of the presence or absence of a burst of 200-cps vibration on the index fingertip. The probability of S's reporting the presence of a signal was found to be influenced by the probability of signal occurrence and signal intensity. A family of ROC curves describing the effects of signal probability on response probability for each signal intensity level was interpreted as support of the applicability of signal detection theory to the judgment of cutaneous stimuli. Manipulation of signal intensity and signal probability also led to changes in S's reaction time for saying "yes" and for saying "no" when the signal was present and when it was absent, supporting the conclusion that S's decision time was longer the closer on the sensation continuum a particular sensory observation was to his criterion.

192. Gescheider, G. A., Wright, J. H., Wever, B. J., Kirchner, B. M., & Milligan, E. A. Reaction time as a function of the intensity and probability of occurrence of vibrotactile signals. Perception & Psychophysics, 1969, 5, 18-20.

Three Ss made judgments of the presence or absence of a burst of 60-cps vibration on the index fingertip. The probability of S's reporting the presence of a signal was found to be influenced by signal probability and signal intensity. Mean reaction time for reporting the presence of a signal decreased as a function of signal intensity and signal probability whereas mean reaction time for reporting the absence of a signal increased as a function of signal intensity and signal probability. On trials where no signal was presented mean RT for reporting a signal decreased with increases in the signal probability whereas mean RT for reporting the absence of a signal increased with increases in signal probability. The results were interpreted as support for the hypothesis that S's decision time was longer the closer on the sensory continuum a particular observation was to his criterion.

193. Gholson, B., & Hohle, R. H. Choice reaction times to hues printed in conflicting hue names and nonsense words. Journal of Experimental Psychology, 1968, 76, 413-418.

Choice reaction times (RTs) were obtained with 2 and 4 equiprobable alternatives, where the responses identified hues appearing in the form of printed conflicting hue names or as printed nonsense words. Each of 48 Ss (undergraduate students) were presented stimuli from both a 2- and a 4-stimulus list, with ½ presented the same hues in conflicting hue names, and the other ½ of the Ss presented the same hues appearing as nonsense words. Each hue was presented 30 times within each list length, appearing equally often in conjunction with each of the 3 conflicting hue names than for comparable nonsense words, and increased significantly with list length for both types of stimuli. Effects of the experimental variables on extimated hypothetical components of RT were also analyzed and interpreted.

194. Gholson, B., & Hohle, R. H. Verbal reactions to hues vs hue names and forms vs form names. Perception & Psychophysics, 1968, 3, 191-196.

Two choice reaction time (RT) studies were carried out in which different classes of stimuli--hues vs hue names in one study and forms vs form names in the other--occurred in independent lists of 2, 4, and 6 equally probable alternatives. Mean choice RTs were faster for hue names and form names than for hues and forms with 4 and 6 alternatives but no significant differences were found in the 2-stimulus list. In both studies, significant list length by stimulus type (e.g., hues vs hue names) interactions indicated greater increase in mean RT with increases in list length for forms and hues than for form names and hue names. It was concluded that differential amounts of generalization of interference accounted for the interactions. Effects of experimental variables on inferred components of RT were also examined.

195. Goldstone, S. Reaction time to onset and termination of lights and sounds. Perceptual and Motor Skills, 1968, 27, 1023-1029.

An experiment was conducted which measured the RT of 40 adult Ss to the onset and termination of rapid rise and decay lights and sounds which had been equated for subjective intensity. Onset RT was faster than termination for both sense modes, and auditory RT was faster than visual for both onset and termination. The results are compared with previous intersensory and onset-termination RT research and with another auditory-visual difference in the judgment of duration.

196. Gordon, I. E. Stimulus probability and simple reaction time. Nature, 1967, 215, 895-896.

Examined the relationship between probability of stimulus (PS) and RT over a wide range of PS values in a sequential, simple RT situation. A click followed a brief flash which served as a warning. Ss responded to the click by closing a microswitch. The rate of presentation of the flash was adjusted inversely to PS. 6 college students were informed of the value of PS and were given a practice period. 50 RTs were measured for each session. Results indicate that the use of catch trials may effect mean latency "by shifting the distribution of reaction times." Also, the RT "task may be considered as a pay-off situation."

197. Gottsdanker, R. The effect of superseding signals. Quarterly Journal of Experimental Psychology, 1966, 18, 236-249.

Eight adult human subjects were given a step-tracking task in which an occasional second signal within 50, 70, 90, 120, or 240 millisec. called for curtailing or reversing the first command. It was found for inter-signal intervals throught 120 millisec. that the shorter the interval the greater was the reduction in amplitude and duration of the majority of responses, with no delay in the effect of the second signal. Where a larger change of response was called for, reversal rather than curtailment, there was a greater effect. A second signal occuring at the 240 millisec. interval (in almost all cases after the start of the response), had no detectable effect. Since the over-all RT was about 180 millisec., it is evident that for at least the first two-thirds of the RT period the initial response is not typically impervious to the effect of a second signal.

Contrary to the expectations of the uncommitted-period version of the hypothesis of substitutive grouping a reversing signal at the 50 millisec. interval did not yield many reversed responses. Moreover this view cannot accommodate the finding that for intervals through 120 millisec., relatively few distributions of response amplitude can be account for by the summation of instances of response to the first signal alone and to the second signal alone. It is concluded that for these intervals, there were generally either overlapping responses to the two signals or else unitary responses in which the two signals were grouped to produce a combined effect.

198. Gottsdanker, R. Computer determinations of the effect of superseding signals. Acta Psychologica, 1967, 27, 35-44.

The question under consideration is whether psychological refractoriness holds for graded responses made with a single anatomical unit. To answer this question, four adult human Ss were given the task of sliding a pointer to whichever of two lamps was illuminated, the lamps being at different distances from the starting point. Occasionally the lamp remained on for only 40 or 50 msec. simultaneously with the illumination of the other lamp, which was the signal either to curtail or to extend the initial command. Computer analysis is being undertaken to find the interval between the appearance of the second signal and its initial effect, under some circumstances definable as RT_2. Procedures have been devised or are being devised to provide meaningful ways of combining data from the time curves of responses on different trials.

199. Gottsdanker, R. Choice reaction time and the nature of the choice response. Psychonomic Science, 1969, 14, 257-270.

Difference between choice and simple RT (reaction time) was much smaller on a step-tracking task than on ungraded tasks having similarly direct stimulus-response mapping. Explanation of PR (psychological refractoriness) by noncongruent response organizations was thus supported. On step tracking, choice RT was less than 10 msec longer than simple RT, implying that the processing steps either took little more told time or else had overlapping aspects.

200. Gottsdanker, R., Broadbent, L., & Van Sant, C. Reaction time to single and to first signals. Journal of Experimental Psychology, 1963, 66, 163-167.

Choice reaction times were measured for 6 adult Ss by 2 procedures. There was a Single-Choice condition in which, after a fixed warning interval, S was required to move a lever away from himself or toward himself according to which of 2 signal lamps was lighted. In the double-choice condition, there followed ½ sec. after the 1st signal a 2nd choice involving 2 other signal lamps and a choice by the other hand. For each S, mean reaction time for the Single-choice condition was reliably shorter than that for the 1st choice in the Double-Choice condition. This was regarded as corroboration of Poulton's thesis that a person's manner of response, including latency, is influenced by his expectations of the requirements of the immediate future.

201. Gottsdanker, R., & Way, T. C. Varied and constant intersignal intervals in psychological refractoriness. Journal of Experimental Psychology, 1966, 72, 792-804.

Choice responses to 2 successive signals were made by 8 young men with both randomly varied and constant intersignal intervals, ranging from 50 to 800 msec. "Delay" interpretations of psychological refractoriness were disconfirmed by quantitative tests, and evidence was against grouping explanations of this failure. The extent to which refractoriness is related to time uncertainty was not extablished definitively. Although RT_2 and less degree than with varied intervals, the values of RT_2 for the constant condition are suspect because of the marked variation of RT_1 with interval. The "organization-persistence" prediction of higher RT_2 when opposite responses were required to the 2 signals was not relized, possibly because of expectation of reversals.

202. Gregg, L. W., & Brogden, W. J. The relation between reaction time and the duration of the auditory stimulus. Journal of Comparative and Physiological Psychology, 1950, 43, 389-395.

In order to determine whether or not the difference in reaction time to fixed duration and to response terminated auditory stimuli as a function of duration may be explained in terms of reaction time to the fixed duration stimuli alone, subjects were given trials with auditory stimuli of 100, 200, 400, 800, 1600, and 2400 ms. duration. When scale values of 1, 2, 3, 4, 5, and 5.5 were assigned to these durations, a linear function was obtained. Comparison of this function with the one obtained by Gregg and Brogden (4) when response terminated trials were given either before or after the reaction trials for the given duration revealed no statistically significant difference between the slopes of the straight lines fitted to the two sets of data. This evidence indicates that reaction time to the auditory stimulus as a function of stumulus duration is the primary relation and that this relation is merely reflected by the relation of duration to the differences in reaction time made to fixed duration and response terminated stimuli.

Additional evidence was obtained from the results of a control group that received only the response terminated condition. The mean of this group did not differ significantly from the mean reaction time to the response terminated stimuli which were presented in conjunction with the fixed duration stimuli (4).

The result of these investigations were presented as linear functions obtained when scale values of 1, 2, 3, 4, 5, and 5.5 were asigned to the stimulus durations of 100, 200, 400, 800, 1600, and 2400 ms. This assignment is based on the assumption that a geometric progression of stimulus duration yields interval units. Since no verification of this is given, the functions remain related to these units that must serve until more exact scaling of duration is obtained.

203. Grier, J. B. Reaction time to "tone-off". Psychonomic Science, 1966, 5, 385-386.

Fifteen college students gave reactions to both the onset and end of a 1000cps tone. After a few initial trials in which the Ss seemed to be adjusting to the novelty of responding at a signal's end, reaction times were significantly shorter to the end of the tone than to its onset.

204. Grier, J. B. Auditory reaction time as a function of stimulus intensity and rise time. Psychonomic Science, 1966, 6, 307-308.

Six levels of stimulus intensity were combined factorially with six different rise times in an auditory reaction time experiment using a 1000cps tone. Rise time had a simple effect on reponses; the longer the rise time, the slower the responses. The magnitude of this effect was larger than could be accounted for by the fact that slower rising tones take longer to reach threshold. Intensity interacted with rise time so that for fast rises (0.5 msec.) intensity had no influence on the speed of reactions. It was only as the rate of loading the auditory system became more gradual that an intensity-reaction time function was obtained.

205. Griew, S. Age, information transmission and the positional relationship between signals and responses in the performance of a choice task. Ergonomics, 1964, 7, 267-277.

Four multiple-choice reaction time experiments are reported. In the first, S-R compatibility is maintained at a high level by requiring subjects to respond by making a movement indicated directly by the position of the signal. In the second, subjects are required to respond in the direction indicated by the position of the 'mirror image' of the signal, and hence S-R compatibility is reduced. Rates of information transmission are calculated from the slope constants of the regression equations fitted to data on mean reaction times. It is found that whilst all subjects show a lower rate of information transmission in the second task than in the first, the reduction in the case of older subjects is not proportionally different from that shown by younger subjects.

The third experiment tests predictions about the mean reaction times of subjects in tasks involving incomptatible S-R relationships which are limited to certain sub-arrays of signals: the prediction is that mean reaction time will be proportional to $(\log_2 N)+(\log_2 N')$, where N=the total number of signals in the array, and N'=the number of signals in the sub-arrays within which incompatibility occurs. Of four specific predictions which are made, three are confirmed.

The fourth experiment investigates individual differences by repeating the third experiment on a sample of subjects drawn from a population radically different from that employed in the third experiment. In this case only two predictions out of four are confirmed, and all observed mean reaction times seem to be proportional to $(\log_2 N)+(\log_2 2)$.

206. Grim, P. F., & White, S. H. Effects of stimulus change upon the GSR and reaction time. Journal of Experimental Psychology, 1965, 69, 276-281.

60 Ss were given 16 RT trials using a colored light as stimulus and then, without warning, lights differing in color but not in intensity were presented. Augmented GSR reactions occurred as a monotonic function of amount of change. Lengthened RTs were also observed; the amount of such lengthening did not appear to be simply related either to evoked GSR or to amount of stimulus change.

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207.. Haider, M. Vigilance, attention, expectation and cortical evoked potentials. Acta Psychologica, 1967, 27, 246-252.

Computer-averaged evoked potentials were recorded and clicks from subjects performing vigilance tasks as well as tasks requiring selective attention, expectation and anticipation. Fluctuations in vigilance performance were accompanied by corresponding changes in evoked potentials. Missed signals showed lower evoked response amplitudes as detected signals. During selective attention responses were larger when attention was directed toward the stimuli. In the expectation studies an 'expectancy potential' could be demonstrated at the instants when the stimulus was expected but did not actually occur. On the other hand, the prominent negative peak of evoked responses appeared later, if the stimulus occurred earlier than expected.

208. Hale, D. J. Sequential analysis of effects of time uncertainty on choice reaction time. Perceptual and Motor Skills, 1967, 25, 285-288.

Foreperiods (FPs) of 0.6, 2, and 4 sec. were used in a 2-choice reaction time (RT) task. Average RT increased with increase in foreperiod. A 'negative recency RT' effect was found where repeated RTs were slower than alternated RTs. Analysis of RTs according to position in sequences of runs reveals a similarly shaped curve for all foreperiods. The effect of increased foreperiod is to increase the RTs of all positions in the sequence. A model for this sequential effect is discussed.

209. Hale, D. J. Sequential effects in a two-choice serial reaction task. Quarterly Journal of Experimental Psychology, 1967, 19, 133-141.

Twenty-four subjects performed a symbolic two-choice serial reaction task under four conditions. These were with a delay from previous response to onset of next stimulus of 100 millisec, 600 millisec., 2 sec., and a fourth condition of 2 sec. delay with verbal prediction of the next stimulus. A positive recency or repetition effect occurred at 100 millisec. delay where RTs to repeated stimuli were faster than RTs to alternate stimuli. At 600 millisec. this effect was still present, though much reduced. The 2 sec. delay gave a negative recency effect where RTs were slower to repeated than to alternate stimuli. This effect increased significantly with simultaneous prediction of the next stimulus. The verbal predictions themselves displayed negative recency. Run analysis of the four conditions revealed striking differences. These results emphasize the need for analysing the microstructure of choice RT situations and reveal deficiencies in present models.

210. Hale, D. J. The relation of correct and error responses in a serial choice reaction task. Psychonomic Science, 1968, 13, 299-301.

Error and correct response times were calculated for a serial choice task with two, four, and eight alternatives over five sessions practice. Error RTs were faster than corresponding correct RTs and varied in the same way as the correct RTs with different numbers of alternatives and degree of practice. Error RT were analyzed in detail according to sequential transitions. Eighty-five per cent of errors directly following errors were attempts at error correction. These results are discussed in terms of serial classification and statistical decision models.

211. Hale, D. J. Repetition and probability effects in a serial choice reaction task. Acta Psychologica, 1969, 29, 163-171.

Each of five subjects in one of three groups performed 5,000 reactions on either a 2, 4, or 8 choice serial choice reaction task. Reaction Time (RT) and errors were analysed for four sequence position - runs, alternations, rank alternations and intervals. The usual repetition effect occurred at all choice levels and as repeated RT decreased during a run so did the RT from the following alternation. There was a smaller probability estimation effect with the interval analysis and a very slight effect for rank alternations. The results demonstrate the simultaneous and interdependent operation of repetition and probability mechanisms.

212. Hale, D. J. Speed/error tradeoff in a three choice serial reaction task. Journal of Experimental Psychology, 1969, in press.

In one experiment speed and accuracy were alternately and separately emphasized in a self-paced serial three choice task with no R-S delay. Ss consistently adopted speed or accuracy sets. The faster overall performance under speed set was due to 1) faster correct responses, 2) faster error responses and 3) additional faster error responses. There was a general speeding of RT distributions and no specific effects were found in digram or sequential analysis. In a second experiment Ss traded off accuracy for speed making up to 50% errors. Overall mean RT decreased linearly and information transmission decreased curvi-linearly with increasing errors but RT was linearly related to information in bits/symbol. Error RT was again faster than correct RT by a similar amount over the error range. These results reveal deficiencies in both serial classification and statistical decision models.

213. Halliday, A. M., Kerr, M.,& Elithorn, A. Grouping of stimuli and apparent exceptions to the psychological refractory period. Quarterly Journal Experimental Psychology, 1960, 12, 72-89.

When a subject is called upon to respond independently to two stimuli, the second of the two responses is often delayed if the stimuli follow closely on one another, and this has led to the suggestion that in making decisions the human operator accepts and organizes the available input information intermittently in the manner of a discontinuous servo. According to this view two nearly simultaneous stimuli can only be dealt with equally fast if they are grouped into a single decision to respond to both stimuli; otherwise one will have to wait for the attention of the central mechanism until the other has been dealt with. In the present experiment it is shown that delays in the second response are not necessary or invariable, and that the pattern and timing of the second responses when they are performed without delay differ in important respects from those to be expected of grouped responses. It is concluded that the central mechanisms concerned in the response do not possess the limitations that the single channel theory would suggest.

214. Hannes, M. The effect of stimulus repetitions and alternations on one-finger and two-finger responding in two-choice reaction time. Journal of Psychology, 1968, 69, 161-164.

An experiment was carried out to clarify the role of stimulus repetitions and stimulus alternations on two-choice reaction time. Specifically, the following hypothesis was tested: the effect of stimulus alternations and stimulus repetitions on one-finger and two-finger response systems is different. Twenty Ss were randomly assigned to two groups. The one-finger group was significantly faster ($p < .01$) to stimulus alternations, whereas the two-finger group was significantly faster to stimulus repetitions ($p < .05$). The results were thus consistent with the hypothesis.

215. Hannes, M., Sutton, S., & Zubin, J. Reaction time: Stimulus uncertainty with response certainty. Journal of General Psychology, 1968, 78, 165-181.

Reaction time to one of two alternative stimuli (sound) is considered as a function of varying sequential dependency in a situation in which response information and transmitted information are zero: i.e., the S makes the identical response regardless of stimulus. It was found that (a) despite the fact that only stimulus information is varied, reaction time to sequentially uncertain stimuli is longer than reaction time to sequentially certain stimuli; (b) reaction time is sensitive to the degree of stimulus uncertainty if the sequence involves no shift in sensory modality; (c) when averaging across two Ss, the relationship between reaction time and stimulus information is linear if the sequence is crossmodal; and (d) practice does no appear to alter these relations.

216. Hardesty, D., & Bevan, W. Forms of orally-presented knowledge of results and serial reaction time. Psychological Record, 1964, 14, 445-448.

The influence of differences in the form of orally-presented knowledge of results upon serial reaction time to a visual signal was studied in four groups: a control group which received no knowledge of results, a group given actual reaction times in msec., a group in which knowledge was provided through a monitor's comments of "very good" or "too slow," and a group receiving both types of reinforcement. The control group showed the usual decrement in performance over successive trials. All reinforcement groups displayed facilitated performance. While the group receiving quantitative information was not reliably superior to that receiving evaluative comment, the best performance was obtained in the group allowed both kinds of knowledge of results.

217. Harrison, K., & Fox, R. Replication of reaction time to stimuli masked by metacontrast. Journal of Experimental Psychology, 1966, 71, 162-163.

Fehrer and Raab (1962) investigated the effects of metacontrast masking of a test flash upon the reaction time (RT) elicited and found that RT was determined solely by the luminance and duration of the test stimulus. The present experiment repeated the major portion of their study for both foveal and peripheral presentation conditions with asynchronies (Δt) between test (5-msec. duration) and mask (50-msec. duration) of 0, 25, 50, 75 and 100 msec. The data indicated that phenomenal diminution of the brightness of the test flash does not produce an increase in RT, a result consistent with that obtained by Fehrer and Raab.

218. Harter, M. R., & White, C. T. Periodicity within reaction time distributions and electromyograms. Quarterly Journal of Experimental Psychology, 1968, 20, 157-166.

This study investigates a periodic component in reaction time frequency distribution, that is a tendency for responses to occur at regular, discrete intervals of time after stimulus presentation. Reaction time frequency distributions were plotted by a Computer of Average Transients and were obtained under stimulus conditions varying in sense modality stimulated (auditory and visual), and the intensity, colour, and duration of stimulation. The results indicated that there was periodicity in reaction time frequency distributions with a modal period of approximately 25 msec. It was found that the periodicty (a) was most evident when there was considerable variability in reaction time, and (b) tended to attenuate when a large number of reaction times were grouped. Other stimulus conditions appeared to have little effect on the periodicity. A significant correlation was found between the frequency of periodicity in the reaction time distributions and the electromyograms, both having a modal period of 25 msec. It was concluded that the periodicity in reaction time was the result of motor processes.

219. Hellyer, S. Stimulus-response coding and amount of information as determinants of reaction time. Journal of Experimental Psychology, 1963, 65, 521-522.

Earlier investigators have shown reaction time and stimulus information to be linearly related with a slope dependent upon amount of pre-experimental practice. Five housewives were run on three tasks varying in pre-experimental practice; light-naming, reading names from slides, and number-naming. Amount of information was varied from one to three bits. The results confirmed the linear relationship with the slope a decreasing function of pre-experimental practice. However, even after 5040 trials on the task with the least such practice, light-naming, differences in reaction time corresponding to differences in information amount had decreased but little, indicating that the information effect is stable, at least for relatively unusual tasks.

220. Helson, H. Current trends and issues in adaptation-level theory. American Psychologist, 1964, 19, 26-38.

"Using a light stimulus followed by a tone, or a tone stimulus followed by a light, we found that from simultaneous presentation of the two stimuli up to about 25-35 msec., response to the first stimulus was facilitated, i.e., quickened, and at 50 msec. up to about 175 msec. response to the first stimulus was inhibited, i.e., slowed. The neutral or equilibrium condition in which the second stimulus neither facititated nor inhibted response to the first stimulus proved to be in the region of 25-35 msec."

221. Helson, H., & Steger, J. A. On the inhibitory effects of a second stimulus following the primary stimulus to react. Journal of Experimental Psychology, 1962, 64, 201-205.

An earlier finding that a light following a sound or a sound following a light after an interval of 75 msec. lengthened RT to the stimulus first presented was verified in the present experiment in which the stimuli were both visual. RT to S_1 was significantly increased when S_2 followed S_1 at intervals ranging from 10 to 170 msec. with the maximum effect occurring from 40 to 140 msec. Trend analysis showed the quadratic components in the Intervals X RT data to be significant. While RT with S_2 present decreases with practice, the greater improvement of control Ss as compared with experimental Ss shows that the inhibitory effect of S_2 on S_1 is not completely negated by 360 repetitions. Four of the 10 experimental Ss failed to give significantly lengthened RTs over all 18 intervals although they did have significantly higher RTs at some of the intervals. While the individual differences and results of practice seem to argue in favor of attitudinal factors as responsible for the effect, other facts argue against this explanation. Two hypotheses were discussed but neither seems completely satisfactory to explain all the facts.

222. Henry, F. M. Reaction time-movement time correlations. Perceptual and Motor Skills, 1961, 12, 63-66.

A correlation of .02 was found between the RT and MT scores of 120 Ss; it was not changed by removing skewness from the score distributions. Variance analysis of regression excluded non-linearity as a possible cause of the low correlation, thus justifying the conclusion that individual differences in RT and MT are independent and unrelated under the conditions of the experiment.

223. Henry, F. M. Response to the Pierson and Rasch comments on RT-MT correlations. Perceptual and Motor Skills, 1961, 12, 258.

224. Henry, F. M., & Harrison, J. S. Refractoriness of a fast movement. Perceptual and Motor Skills, 1961, 13, 351-354.

A 91-cm. forward arm swing made at maximal speed was found resistant to attempts at movement reversal. While the reversal could be initiated to a statistically significant extent by signals that followed the primary stimulus within an interval of .19 sec. or less, slowing of the movement preliminary to reversal occurred .41 sec. after the initial stimulus and the arm could seldom be stopped before traveling the full distance to the target. It is concluded that the results are consistent with predictions from current movement theory.

225. Herman, L. M. Effects of second signals on response time to first signals under certainty and uncertainty. Journal of Experimental Psychology, 1969, 80, 106-112.

The effects of a second signal (S2) on response time (RT) to a first signal (S1) were investigated. Three groups of 16 Ss, matched for response speed on a pretest, were subsequently tested for RT to an S1 light under (a) stimulus-response certainty and (b) stimulus-response uncertainty. For Groups 1 and 2, an S2 light, requiring no response, followed S1 at interstimulus intervals (ISIs)of either 50, 100, or 150 msec., randomly selected, or not at all. For Group 1, two lights were in a reciprocal relation as S1 and S2; if one flashed on first, the other became the potential S2 light. For Group 2, the same two lights served as S1, but a third light was used exclusively for S2. Group 3 was never exposed to an S2 light. Results showed no significant group differences under the certainty condition. Under uncertainty, RT for Group 1 was significantly longer than that for either Group 2 or Group 3, but the latter two groups did not differ significantly. These effects were independent of ISI. The results were interpreted in terms of response-conflict views of double-stimulation effects.

226. Herman, L. M., & Israel, A. Decremental and facilitatory effects of second signals on response time to first signals under differenct levels of uncertainty. Proceedings, 75th Annual Convention, American Psychological Association, 1967, 2, 27-28.

Helson and Steger (1962) reported that under stimulus certainty and irrelevant signal (S2) 10-180 msec. following an indicated signal (S1) to respond delayed simple response time (RT). Expectancy (Adams, 1964) and response time conflict (Reynolds, (1964) interpretations have been given to the data, but subsequent studies (Koplin, Fox, & Dozier, 1966; Lappin & Ericksen, 1964) have failed to support the original findings. Koplin et al. also failed to find inhibitory effects of S2 under prior uncertainty (U) for S as to which for two signals would serve as S1 on a given trial; their design in this case, however, lacked a "no S2" control group, for assessment of any general decremental effects of S2.

The present study examines effects of S2 for different levels of U (1, 2, or 3 bits), using an independent-groups design to test for effects of S2. At each U level, four S1-S2 intervals are studied. In addition, effects of S2 on response latency to S1 are compared when S2 signals a response (a) opposing that being organized for S1 or (b) corresponding to that being organized for S1. This latter variable permits examination of whether S2 can differentially retard or facilitate the "unfolding" response to S1.

227. Herman, L. M., & Kantowitz, B. H. Effects of second signals occuring after response selection on responses to first signals. Journal of Experimental Psychology, 1969, 80, 570-572.

Following a first signal to respond (S1), a second signal (S2) to which no response was required was inserted during response execution, i.e., after an overt response to S1 had begun but before the entire response had been completed. No significant decrements in response latency to S1 or in errors in responding to S1 were found by comparison with an independent control group never experiencing S2. This was in contrast to prior findings in which significant response decrements had been found when S2 occurred during response selection i.e., prior to initiation of any overt movement. The set of findings were considered compatible with an interpretation of independence of response-selection and response-execution stages and with response-conflict theory.

228. Herman, L. M., & McCauley, M. E. Delay in responding to the first stimulus in the "psychological refractory period" experiment: Comparisons with delay produced by a second stimulus no requiring a response. Journal of Experimental Psychology, 1969, in press.

229. Hershberger, W. A., Trantina, P. R.,& Cosgrove, K. Letter-naming time as a function of set familiarity and symbol distinctiveness. Quarterly Journal of Experimental Psychology, 1968, 20, 395-399.

Two symbol-naming experiments were conducted assessing the dependence of Fitts and Switzer's set-familiarity effects upon symbol distinctiveness. Sixty college males named printed letters presented in a strobotron tachistoscope, the letter always being selected from a preannounced set of three. A voice key detected the response. Experiment I found the Fitts and Switzer finding to be a joint effect: response latency for naming the symbol B in the unfamiliar but distinctive set, VBO, was intermediate to that for the familiar distinctive set, ABC, and the unfamiliar, homolographic set, PBE, the two sets used by Fitts and Switzer. Experiment II, a factorial combination of set familiarity and symbol distinctiveness yielded a significant interaction such that with homolographic symbols, set familiarity was associated with an increase in reaction time. The results were interpreted as consistent with an hypothesis that the set-familiarity effect relates to symbol-identification time as opposed to response-identification time.

230. Hershenson, M. Reaction time as a measure of intersensory facilitation. Journal of Experimental Psychology, 1962, 63, 289-293.

An experiment is reported in which RTs were measured to light and sound presented singly and in combination. The chief experimental variable was stimulus onset scynchrony. The results may be summarized as follows: (a) Intersensory facilitation was demonstrated in that, for certain asynchronies, RTs were faster to the combination than to either stimulus alone. (b) Maximum facilitation occurred at or just beyond the point at which the asychrony was equal to the difference in RT to the single stimuli. (c) Varying the intensity of the stimuli differentially affected the magnitude of facilitation. Reducing the light intensity resulted in less facilitation whereas reducing the sound intensity had no effect.

231. Hick, W. E. On the rate of gain of information. Quarterly Journal of Experimental Psychology, 1952, 4, 11-26.

The analytical methods of information theory are applied to the data obtained in certain choice-reaction-time experiments. Two types of experiment were performed: (a) a conventional choice-reaction experiment, with various numbers of alternatives up to ten, and with a negligible proportion of errors, and (b) a ten-choice experiment in which the subjects deliberately reduced their reaction time by allowing themselves various proportions of errors.

The principal finding is that the rate of gain of information is, on the average constant with respect to time, withing the duration of one perceptual-motor act, and has a value of the order of five "bits" per second.

The distribution of reaction times among the ten stimuli in the second experiment is shown to be related to the objective uncertainty as to which response will be given to each stimulus. The distribution of reaction times among the response is also related to the same uncertainty. This is further evidence that information is intimately concerned with reaction time.

Some possible conceptual models of the process are considered, but tests against the data are inconclusive.

232. Hick, W. E., & Welford, A. T. Central inhibition: Some refractory observations. (Two comments on the paper by Alick Elithorn and Catherine Lawrence) Quarterly Journal of Experimental Psychology, 1956, 8, 39 40.

233. Hilgendorf, L. Information input and response time. Ergonomics, 1966, 9, 31-37.

A study of the relationship between information input and response times used visually presented, discrete symbols from six alphabets of up to 1000 alternatives and a key-pressing response. It was found that RT varied directly with information content ($\log_2 n$) with no tendency to deviate from a straight line at high levels of n. Three further experiments are suggested.

234. Hofmann, M. Response times to electrocutaneous stimulation. Perceptual and Motor Skills, 1967, 25, 509-513.

Response times were obtained from 9 Ss responding to DC electrocutaneous signals. Each S received a series of 160 signals varying randomly in inter-signal interval (response to onset of next signal) and location. The results indicated that of the 5 inter-signal intervals employed, those being 7, 10, and 12 sec. in duration produced faster mean response times than those of 2 and 4 sec. Response times to the locations, the left hand, left foot, right hand, and right foot, did not differ significantly from one another but significantly interacted with Ss.

235. Hohle, R. H. Inferred components of reaction times as functions of foreperiod duration. Journal of Experimental Psychology, 1965, 69, 382-386.

A distribution function representing simple reaction-time distributions was derived, assuming RT is the sum of 2 component variables with exponential and normal distributions. Four Ss gave 100 RTs to an auditory stimulus following each of 4 foreperiods, under each of 2 conditions: (a) foreperiod constant within sessions but varied over sessions, and (b) foreperiods appearing in a random sequence. The derived distribution function provided completely satisfactory representations of all 32 RT distributions, and the relations of the fitted parameters of this function to foreperiod suggest that the variation of RT as a function of foreperiod is due to variation in the normally distributed component.

236. Hohle, R. H. Component process latencies in reaction times of children and adults. In Advances in child development and behavior. Vol. 3. New York: Academic Press Inc., 1967. p. 225-261.

A number of RT studies using child Ss were reviewed, and it was suggested that development of the reactive process might be better understood if more information were available on the underlying processes producing variations in RT. Three approaches were described, each directed toward identifying and determining the latencies of some of the various processes intervening between the stimulus and response in an RT situation: (1) variation of the task of S such that different numbers of hypothetical component processes are involved, then comparing mean RTs under the different task conditions: (2) direct measurement of portions of total RTs: and (3) inferring component latencies from statistical distributions of total RTs.

The last of these approaches was developed in this paper. A specific distribution function was proposed to describe RT distributions, derived from the assumption that observed RTs can be represented as sums of two random variables, one having an exponential distribution, the other a normal distribution. A method of estimating the parameters of this function was described and the degree of correspondence was examined between fitted theoretical functions and 240 obtained distributions of RTs, taken from four different studies. While this correspondence was not completely satisfactory under all conditions, it seemed sufficiently close generally to warrant examination of the relations of the distribution parameters to several experimental variables.

237. Hohle, R. H., & Gholson, B. Choice reaction times with equally and unequally probable alternatives. Journal of Experimental Psychology, 1969, in press.

Choice reaction times (RTs) were obtained from two groups of adult female Ss under two conditions. Ss in one group (n=9) were presented three sets of stimuli (geometrical forms) with 2, 4, and 8 alternatives, where the alternatives were presented with equal relative frequencies. A 2nd group (n=8) received a sequence of trials on 4 different stimuli presented with relative frequencies of .50, .25, .125, and .125. Choice RT was an increasing, approximately linear, function of the negative logarithm of the relative frequency of occurrence of a stimulus for each group, but the slope of the function was significantly greater for the group receiving stimuli with equal relative frequencies. Choice RTs on trials on which the stimulus was the same as that on the immediately preceding trial were significantly faster than on non-repeat trials.

238. Horiuchi, H. Effects of auditory vs. visual presentation on discrimination reaction time. Psychologia: An International Journal of Psychology in the Orient, 1966, 9, 85-90.

To study the channels of presentation, the effects of auditory vs. visual presentation affecting discrimination reaction time (DRT) were investigated. One of the six digits, "4, 5, 6, 7, 8, 9," was presented auditorially (A) or visually (V), but the Ss responded only to the odd number, saying "Yes". Channels of presentation were: (1) A only, (2) V only, (3) A-V redundant, (4) V interference, (5) A interference, (6) left (L) only, and (7) right (R) only. Six female Ss served in each condition. To avoid the phenomena accompanying stimulus onset, a digital discharge tube was applied to V presentation. Digital counter was used for measuring DRT. In general, it seems that A (or R) presentation is superior to V (or L) presentation on DRT.

239. Howell, W. C. On the heterogeneity of stimulus and response elements in the processing of information. Journal of Experimental Psychology, 1962, 63, 235-243.

Three experiments were carried out to determine the influence of stimulus (S), response (R), and S-R or task heterogeneity on simple information-processing performance. Heterogeneity was provided by two dissimilar S classes (auditory vs. visual) and two dissemilar R classes (manual vs. verbal). The conditions were the types of heterogeneity noted above plus a set of homogeneous control conditions. Under all conditions there were six alternative Ss and six associated Rs; 300 serial S-R occurrences comprised each task. The major performance index was average rate of information transmitted (H_t/sec). Eighteen Ss served under each of the three heterogeneity conditions and 9 served under each of the four homogeneous control conditions.

The major results were: (a) For the particular stimulus and response classes used there appeared no evidence for S-R compatibility differences, and compatibility generally was low. (b) In support of earlier findings, the visual code was superior to the auditory code; contrary to earlier findings, the manual response mode was superior to the verbal response mode. (c) Task heterogeneity led to significantly higher rates of information transmission than did task homogeneity. (d) The task heterogeneity effect may be attributed partially to the S component, since S heterogeneity also enhanced performance significantly over the homogeneous controls, whereas R heterogeneity did not. Neither S nor R heterogeneity scores differed significantly from task heterogeneity scores.

From these findings it is concluded that simple information-processing performance may be enhanced by the presence, in certain amounts, of stimulus or task heterogeneity. The most effective heterogeneity level for any particular task, however, is probably determined by a number of other task variables.

240. Howell, W. C., & Donaldson, J. E. Human choice reaction time within and among sense modalities. Science, 1962, 135, 429-430.

Human choice reaction time was studied as a function of sense modality and inter- versus intrasensory coding at three levels of stimulus strength. Unlike the case in earlier studies, stimulus strength was equated across sense modalities. Classical findings were supported for strength and modality; intersensory coding was superior to intrasensory coding.

241. Howell, W. C., & Kriedler, D. L. Information processing under contradictory instructional sets. Journal of Experimental Psychology, 1963, 65, 39-46.

Key pressing in response to spatially coded visual signals was studied as a function of 4 sets of instructions: (a) speed-accuracy, (b) speed, (c) accuracy, and (d) transmission rate (H_t/sec). Contradictory (speed-accuracy) and noncontradictory (H_t/sec) instructions resulted in comparable acquisition and performance functions on all 3 measures taken: speed, accuracy, H_t/sec. Behavior under conflicting instructions corresponded more closely to that for accuracy than to that for speed; S appeared to select a high accuracy criterion and to adjust speed to the maximum level permitted by it. Speed instructions caused S to lower his accuracy criterion appreciably, but with little compensation in increased speed.

242. Hughes, I. M. Crossman's confusion-function and multi-choice discrimination. Quarterly Journal of Experimental Psychology, 1964, 16, 177-180.

243. Hyman, R. Stimulus information as a determinant of reaction time. Journal of Experimental Psychology, 1953, 45, 188-196.

The reaction time to a visual stimulus was investigated as a function of the amount of information conveyed by that stimulus. The amount of information in the stimulus was varied by varying (a) the number of equally probable alternatives from which it could be chosen, (b) the proportion of times it could occur relative to the other possible alternatives, and (c) the probability of its occurrence as a function of the immediately proceding stimulus presentation.

The reaction time to the amount of information in the stimulus produced a linear regression for each of the three ways in which information was varied.

The three regression lines obtained by the three separate ways of varying the amount of information were found to coincide for three Ss. In the case of the fourth S, a systematic displacement of one of his regression lines was attributed to a relatively large practice effect which he showed for that experiment.

244. Hyman, R., & Umilta, C. The information hypothesis and non-repetitions. Acta Psychologica, 1969, in press.

The information hypothesis specifies that equi-information conditions will yield the same mean RT provided that S can and does take advantage of all the information available to him prior to the occurrence of each new signal. KORNBLUM's recent experiment (1968) demonstrated RT was not the same for equi-information condition differing in proportion of repetitions. One can conclude with KORNBLUM that his findings disconfirm the information hypothesis or one can look for factors in the experimental situation that may have impeded Ss ability to profit from information in alternations. When we repeated three of KORNBLUM's conditions in a choice reaction experiment designed to give S more opportunity to use the information from alternations, the overall results were more compatible with the information hypothesis. This result suggests that a fruitful way to study the microstructure of choice RT is to isolate the factors that differentiate situations in which the information hypothesis holds form those in which it does not.

J

245. Jarl, V. C. Methods of stimulus presentation as antecedent variable in reaction time experiments. Acta Psychologica, 1957, 13, 225-241.

Preknowledge of the stimulus and the stimulus presented irregularly produce different results. In the latter case, the adoption of systematically different preparatory sets is excluded, and differential effects of the stimuli may then be ascribed to receptor or S factors. There is evidence that the differential effect of stimulus strength is not the same under the 2 procedures. Results are consistent with the hypothesis of a reciprocal, compensatory relationship between sensory adequacy of stimulation and degree of effort on the part of the reacting organism.

246. Jeeves, M. A. Changes in performance at a serial-reaction task under conditions of advance and delay of information. Ergonomics, 1961, 4, 329-338.

An experiment is reported which compared, in a continuous serial choice-reaction task, the effects of giving the display signals at different points either before or after the responding limb was in a position to take appropriate action. The results indicated that substantial elements in the timing of serial, sensori-motor performance are the times required to deal with sensory data arising from limb movements and possibly, although to a lesser extent, times taken to overcome inertia in the apparatus or in a moving limb. The presence of these elements provided an explanation of the fact that advance information did not speed up performance as much as would be expected if the whole of the performance for dealing with the signals in the display.

247. John, I. D. The role of extraneous stimuli in responsiveness to signals: Refractoriness or facilitation? Australian Journal of Psychology, 1964, 16, 87-96.

Two experiments are described in which the effects of visual extraneous stimuli on speed of response to auditory signals were investigated. The findings based on 70 adult Ss were than an extraneous stimulus preceding a signal facilitates responsivenes to the signal and that strength of the effect is related to the interval separating the extraneous stimulus and signal. For intervals of less than 0.2 sec. the magnitude of the effect is also related to the intensity of the extraneous stimulus. The existence of such a facilitatory effect is taken as contradicting the established view of a psychological refractory period and an attempt is made to relate this finding to other studies.

248. John, I. D. Intensity of non-key stimuli in the Donders c-type reaction. Australian Journal of Psychology, 1966, 18, 148-153.

A theoretical model linking Donders' a- and c-type reactions is proposed. It is deduced from the model that in a c-type reaction situation the greater the intensity of the nonkey stimuli the longer will be the RT to key stimuli. The prediction is confirmed at a high level of significance using 24 Ss. Further implications of the findings are discussed.

249. John, I. D. A statistical decision theory of simple reaction time. Australian Journal of Psychology, 1967, 19, 27-34.

The theory is based on the view that simple reactions are prepared responses elicited by the triggering of a response release mechanism which can be preset by S, and treats S's setting of this mechanism as a statistical decision process. The theory is applied with some success to findings concerning the stimulus intensity-RT relationship, motor and sensory preparation, the distribution of RTs, the effect of forewarning signals, the Donders' a- and c-type reactions and so-called psychological refractoriness. It is suggested that the theory may provide a basis for a more adequate conceptual treatment of choice RT.

250. John, I. D. Sequential effects of stimulus characteristics in a serial reaction time task. Australian Journal of Psychology, 1967, 19, 35-40.

Describes an experiment using 20 Ss in a serial auditory RT task, which demonstrates sequential effects of manipulation of stimulus intensity from trial to trial. No such effects are demonstrated with the manipulation of pitch of stimuli. The obtained results confirm predictions from a statistical decision model of simple RT and are interpreted as an adaptation-level effect. The finding is utilized to explain previously established differences between the performance of normals and schizophrenics in serial RT tasks.

251. John, I. D. Intrasensory effects in simple reaction time: A re-analysis of Rubinstein's data. Perceptual and Motor Skills, 1967, 24, 1222.

252. Johnson, H. M. Reaction time measurements. Psychological Bulletin, 1923, 20, 562-589.

253. Jones, L. E., & Parducci, A. Stimulus uncertainty and the latency of category judgment. Psychonomic Science, 1967, 7, 71-72.

The latencies of category judgments of size varied inversely with the skewness of the frequency distribution of stimuli. Although the task did not permit one-to-one identification of the stimuli, the data suggest that one function of category judgment is to reduce the uncertainty about which stimulus has been presented.

K

254. Kamlet, A. S. Processing of sequentially presented signals in information-combining tasks. U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., Technical Memorandum 9-69, 1969.

Human performance theory has relied heavily upon an experimental paradigm in which speeded performance, or reaction time, is measured as a function of the time intervening between two successive stimuli. This study examined a special form of the two-signal paradigm in which the first stimulus proveded the "rule" or "operator" for defining the appropriate response to the second stimulus. This form of the two-signal experimental paradigm is called an information-combining task.

The aim of the present series of experiments was to examine temporal factors in an information-combining task in order to discriminate among alternative human performance theories. Specifically, the number of alternative operators and the number of alternative second signals were independently varied over a range of intervals between the operator and the second signal. In some tests the interstimulus interval was held constant from trial to trial; in other tests the interstimulus interval varied between successive trials.

The findings rejected single-channel theories of information processing in favor of a flexible, capacity-sharing model. The results also suggested that subjects performed sophisticated strategy adjustments to take advantage of subtle features of these information-combining tasks.

255. Kanarick, A. F. Probability and payoff as factors influencing two-choice reaction-time. Journal of Engineering Psychology, 1966, 5, 37-46.

The relative effects of payoff and probability on two-choice reaction-time were investigated. Three levels of probability (.5/.5, .7/.3, and .9/.1) and four levels of payoff (1:1, 2:1, 4:1, and 8:1) were used in factorial combination, with rapid responses to the improbable event rewarded with an amount either equal to or greater than that associated with the more probable event. Response speeds were significantly influenced by both probability and payoff level, probability having the greater effect. The difference in response speeds to the two events was highly correlated with the difference in average gain associated with the events.

256. Karlin, L. Reaction time as a function of foreperiod duration and variability. Journal of Experimental Psychology, 1959, 58, 185-191.

The relationship between RT and foreperiod was studied under two conditions of foreperiod variability. Under one condition there was minimal objective variability, under the other there was 20% objective variability. The latter condition was used in an attempt to reduce the influence of prematurely originated reactions, and provided a method for studying the development of preparation. The results obtained suggested the following:

1. There is no evidence that prematurely originated reactions had an appreciable influence on either condition.

2. Woodrow's finding of a 2-sec. optimum was not confirmed.

3. The steady increase in RT as a function of foreperiod contradicts a previous conclusion (Teichner, 1954) that the optimum lies within a range of from 2 to 8 sec.

4. RT following a given foreperiod was influenced by the magnitude of the foreperiod immediately preceding the given foreperiod.

5. The development of a state of readiness followed a similar course during the three longer blocks of foreperiods which was different from the way in which it developed during the shortest block of foreperiods.

257. Karlin, L. Comments on "expectancy and intermittency". Quarterly Journal of Experimental Psychology, 1965, 17, 351.

258. Karlin, L. Development of readiness to respond during short foreperiods. Journal of Experimental Psychology, 1966, 72, 505-509.

Simple reaction time as a function of foreperiod duration was determined for 6 foreperiod distributions characterized as leptokurtic, bimodal, or rectangular. S's inability to maintain a peak level of readiness geared to the most frequently occurring foreperiod suggested a "ballistic" type of preparation which was relatively independent of the conditional probability of occurrence of the stimulus during the foreperiod.

259. Karlin, L., & Kestenbaum, R. Effects of number of alternatives on the psychological refractory period. Quarterly Journal of Experimental Psychology, 1968, 20, 167-178.

The effects of changing the number of choices in the first response on "psychological refractoriness" were found to be partially consistent with intermittency theory but modifications may be needed to explain the results when the number of choices in the second response is increased.

260. Karlin, L., & Mordkoff, A. M. Decreased reaction time produced by discordant warning and reaction stimuli. Psychonomic Science., 1967, 9, 555.

Decreased reaction time (RT) was obtained when the stimulus modality of the warning signal (WS) differed from that of the reaction stimulus (RS). This effect was obtained only when the interval between the WS and RS was relatively short (.5 sec) and not when it was lengthened to 2 sec.

261. Kaswan, J.,& Young, S. Effect of luminance, exposure duration, and task complexity on reaction time. Journal of Experimental Psychology, 1965, 69, 393-400.

Reaction time to a pattern-discrimination task was found to be equally affected by variation in exposure duration (4-512 msec.) and luminance (.09-11.84 mL.). In a supplementary study of figure-ground detection, it was found that luminance affected RT to a greater extent than exposure duration. Further, it was found that luminance and exposure duration determined different RT functions in the 2 experiments. In the discrimination task there was a gradual shift in the relation of luminance and exposure duration to RT, from inverse at bright and long exposures, to direct at dim and brief exposures. In the detection task, RT was always inversely related to changes in luminance and exposure duration, to the extent to which RT was affected by these variables.

262. Kaswan, J., & Young, S. Effect of stimulus variables on choice reaction times and thresholds. Journal of Experimental Psychology, 1965, 69, 511-514.

For 8 different groups of Ss, individual patterns from sets of either 4-, 3-, or 2-alternative patterns were shown to each S under 2 conditions in a forced-choice recognition task. In one condition, exposure duration was varied by E and thresholds were determined for each pattern. In the other condition, choice reaction times (CRT) were obtained, measured from stimulus onset to S's key press. It was predicted and found that the order of CRTs would parallel the order of thresholds in each combination of patterns. This finding supports the assumption that the time required to receive spatial information sufficient to distinguish patterns is an identifiable component of CRT.

263. Kaufman, H., & Lamb, J. Choice reaction and unequal stimulus frequencies in an absolute judgment situation. Perception & Psychophysic, 1966, 1, 385-388.

Previous investigators have reported discrepant results for Ss in a choice reaction time (CRT) situation when stimuli are not equi-probable. Sixty Ss participated in an absolute judgment CRT task under three conditions of equi-probable stimuli and three of unequally probable stimuli. The results indicate that previous findings may be determined by a threshold dependent upon the effect of unequal stimulus frequencies and the utilities of different response strategies.

264. Kaufman, H., & Levy, R. M. A further test of Hick's law with unequally likely alternatives. Perceptual and Motor Skills, 1966, 22, 967-970.

The present study was designed to replicate Lamb and Kaufman's (1965) findings of a relationship between choice reaction time and transmitted information for equally likely (ELA) and unequally likely (ULA) stimulus alternatives. The possible confounding of variability between sessions and between experimental conditions in the Lamb and Kaufman study was eliminated by using a single S in all experimental sessions. Results, in essential agreement with those of the earlier study, suggest strongly that the essential agreement with those of the earlier study, suggest strongly that the ELA and ULA conditions are fundamentally different as information sources.

265. Kay, H., & Weiss, A. D. Relationship between simple and serial reaction times. Nature, 1961, 191, 790-791.

266. Keele, S. W. Compatibility and time-sharing in serial reaction time. Journal of Experimental Psychology, 1967, 75, 529-539.

The degree of similarity between arrangements of stimulus lights and response contacts, the degree of sequential dependency in the order of the lights, and the difficulty of a time-shared task were manipulated in 2 studies of performance on a serial reaction-time task. Sequential dependencies had no significant effect on performance. Speed of performance was directly related to the similarity of the light and contact arrangements and was an inverse function of the difficulty of the time-shared task. A given time-shared task interfered more with dissimilar light and contact arrangements than with similar arrangements.

267. Keele, S. W. Movement control in skilled motor performance. Psychological Bulletin, 1968, 70, 387-403.

The speed and accuracy of single movements depend on several factors, such as direction of movement, distance to the target, and accompaniment by simultaneous movements. The relation between speed, accuracy, and distance appears to be determined by the time required to process feedback and to make corrective alterations in the movement. For a repetitive series of movements, there is some evidence suggesting that control is shifted from feedback to a motor program. This view receives further support from demonstrations that the reproduction of single movements may be under programmed control. How the study of movements may be relevant to understanding perceptual and memory skills, as well as motor skills, is briefly mentioned.

268. Keele, S. W. Repetition effect: A memory-dependent process. Journal of Experimental Psychology, 1969, 80, 243-248.

In choice reaction time (RT) studies it has commonly been found that RT to a repeated stimulus is faster than to nonrepeated stimuli. The first two experiments tested the hypothesis that this repetition effect is a short-term memory phenomenon and that an increased time interval between stimuli or an interpolated filler task between successive stimuli would abolish the effect. This hypothesis was not supported. A third experiment suggested, instead, that the repetition effect was due to stimulus anticipation and the saving in memory search time with correct anticipations.

269. Keele, S. W., & Posner, M. I. Processing of visual feedback in rapid movements. Journal of Experimental Psychology, 1968, 77, 155-158.

The present study determined the minimum amount of time necessary to process visual feedback from a movement. The Ss rapidly moved a stylus from a home position to a target. On half the trials all lights turned off at the start of the movement so that they were made in the dark. Visual feedback did not facilitate accuracy in hitting the target when the movement was as short as 190 msec. For durations of 260 msec. or longer, having the lights on facilitated accuracy, suggesting that it takes 190-260 msec. to process the feedback.

270. Kerr, M., Mingay, R., & Elithorn, A. Patterns of reaction time responses. British Journal of Psychology, 1965, 56, 53-59.

The reaction time responses of forty-four subjects to paired stimuli separated by an interval of 100 msec. were analysed to test whether there was evidence for several distinct types of response patterns, and, if so, whether these patterns were associated with individual performances.

The analysis confirmed both these hypotheses, six main types of response being distinguishable and the response patterns being markedly different for different individuals.

271. Kintsch, W. A response time model for choice behavior. Psychometrika, 1963, 28, 27-32.

A subject in a two-choice situation characteristically makes several observing responses before performing the final choice. This behavior can be described by means of a random walk model. The present paper explores some possibilities as to how this model can be extended to include choice time. The assumption is made that the duration of each step in the random walk is a random variable which is exponentially distributed. With this assumption, one can predict the probability distributions of the choice times as well as the moments of these distributions.

272. Kirk, N. S., & Feinstein, J. An investigation of the relation between inspection and repairing performance of burlers and menders in the worsted woollen industry. Acta Psychologica, 1967, 27, 213-222.

A comparison is made between two tasks in the woollen industry both of which involve inspection and repairing of faults in a product. Performance on both parts of these tasks was rated and described in a number of measures such as total time of inspection, average repair time, proportion of faults detected, quality of repairs, etc. The main conclusion it that there is no evidence that inspection and repair performance are related. This finding suggests that the perceptual part (inspection) and the motor part (repair) might profitably be separated and carried out by different people.

273. Klemmer, E. T. Time sharing between auditory and visual channels. In Finch and Cameron (eds.) USAF, ARDC Tech. Rept., 1956, No. 56-8, 199-203.

S to alternate regularly between tasks more rapidly than once every 2 sec. lowers his over-all performance sharply. It also appeared that forced time sharing between tasks of different difficulties leads to a greater decrement in performance on the easier task. The average reaction time during alternation was close to that for the more difficult channel alone.

274. Klemmer, E. T. Time uncertainty in simple reaction time. Journal of Experimental Psychology, 1956, 51, 179-184.

Six Ss were given two series of simple reaction-time tests. In the first series the effect of changes in mean foreperiod and foreperiod variability were systemmatically investigated. In the second series the effect of spacing between stimuli was studied with no warning signal. These tests were designed to determine the relation between RT and Ss' uncertainty about time of stimulus presentation.

The results show that RT increases with foreperiod variability and with mean foreperiod above some small optimum value less than 1 sec. In a sequence of trials, the immediate foreperiod influences RT only if the previous foreperiod is different from it, and then only slightly.

The striking finding in all tests with variable foreperiod is that the important determiner of RT is not the immediate foreperiod but rather the distribution of foreperiods within which it is embedded.

275. Klemmer, E. T. Rhythmic disturbances ina simple visual-motor task. American Journal of Psychology, 1957, 70, 56-63.

A series of tests was designed to investigate rhythmic difficulty in key-pressing to flashing lights. All tests were made with a stimulus-repetition rate of 2 per-sec. The stimulus was single lighted lamp mounted alone, or, in other tests, in a bank of five placed in front of five keys. When five lamps were used, the position of the lighted one changed either randomly or regularly. S was instructed to hit one key after each light. In some tests he pressed one out of five keys, in other tests the pressed the same key each time regardless of light position. In only one of the six tests so formed was a discriminative response required, that is, in only one test was S required to transmit information about light-position. In all other tests S knew in advance what each stimulus and response would be.

The results for five Ss on the six tests showed that: (1) Only when there was uncertainty both about the position of the next light and the response to it were all Ss able to maintain a consistent phase-relation between stimulus and response. (2) The lack of discriminative response led either to an irregular distribution of responses over the entire inter-stimulus interval or to a piling up of responses close to the stimulus. (3) Instructions to respond simultaneously with the stimulus produced distributions very similar to those for instructions to respond after each stimulus.

276. Klemmer, E. T. Rate of force application in a simple reaction time test. Journal of Applied Psychology, 1957, 41, 329-332.

An electrical strain gage was fitted to a pressure key and continuous force records were taken during a simple reaction-time experiment. Various levels of holding force previous to stimulus onset were required of S with two widely different amounts of additional force required for the response.

The results of this study may be summarized as follows:

1. RT measured to the first ounce of the response is independent of pre-stimulus

holding forces of zero to 20 ounces.

2. RT measured to the first ounce of the response is the same when a 20-ounce response is required as when only a 1-ounce response is required.

3. Rate of force application between 1 and 20 added ounces is independent of holding forces from 2 to 20 ounces. Zero holding force results in a slightly higher rate of force application.

4. The mean rate of force application for six Ss such that 37 msec. are required to build up from 1 added ounce to 20 added ounces.

5. Between Ss, starting speed of the response is positively correlated with rate of force build-up. Within Ss, starting speed is negatively correlated with rate of force build-up.

6. Variability of RT is unaffected by pre-stimulus holding forces of zero to 20 ounces.

277. Klemmer, E. T. Simple reaction time as a function of time uncertainty. Journal of Experimental Psychology, 1957, 54, 195-200.

Five Ss were given a set of simple RT tests specifically designed to test the hypothesis that a single-valued relation could be obtained between RT and the time uncertainty of the stimulus. This relation was shown to be approximately linear when time uncertaintly is plotted as an informational measure. The slope of the RT-time uncertainty function averaged 18 msec. per bit of stimulus uncertainty which is less than the slope arising from RT experiments involving choice among several stimuli previously reported. Information transmitted in the time domain varied from less than one to more than five bits per stimulus over the 10 tests.

278. Klemmer, E. T. Time sharing between frequency-coded auditory and visual channels. Journal of Experimental Psychology, 1958, 55, 229-235.

Performance on a high-speed key-pressing task was determined for situations in which S: (a) responded to a frequency-coded visual channel (color-coded); (b) responded to a frequency-coded auditory channel (tone-coded); (c) alternated regularly between the visual and auditory channels; (d) alternated randomly between the visual and auditory channels; and (e) responded to simultaneous visual and auditory channels presenting redundant stimuli. Mean reaction times were taken during all tests.

Each of the above tests was given to 5 to 7 trained Ss with the following results:

1. The frequency-coded lights and tones were of approximately equal difficulty; two Ss doing significantly better on the tones, and two on the lights, and three showing insignificant differences.

2. Alternating between channels every 2.5 sec. resulted in little decrement in the light channel. The tone channel dropped 11% in percentage correct score, the two Ss who did better on the separate tone channel showing the largest drop.

3. Increasing the alternation rate to once every .5 sec. dropped percentage correct performance on both channels an additional 26%.

4. Random alternation between channels produced the same performance as regular alternation at the same mean rate.

5. Presenting redundant information in the two channels simultaneously resulted in higher performance than the better single channel for only two of five Ss.

6. The average reaction time was the same for the separate light and tone tests. Alternation between channels increased the reaction time but only by .02 sec. The reduntant-simultaneous presentation gave a reaction time no different from the single channel which had the shorter reaction time in the separate tests.

279. Klemmer, E. T. Communication and human performance. Human Factors, 1962, 4, 75-79.

The communication to which the present paper refers is the flow of information in and out of the human operator while he is performing a well-defined task. The steps in this process, the types of measures required in its analysis, and some recent data in human information processing are outlined. The paper ends with a brief evaluation of the function and the future of computer simulation in improving man-machine communications.

280. Klemmer, E. T. Sequences of responses to signals encoded in time only. Acta Psychologica, 1967, 27, 197-207.

Subjects attempted to press a single key once for each stimulus, for single stimuli occurring in rapid sequence at either regular or random time-intervals. For regularly occurring stimuli, rhythmic difficulties occur at rates of two or three per second. Random intervals between stimuli led to even poorer performance at the same rates. This finding may be explained by the longer reaction times for short intervals between stimuli.

281. Kobrick, J. L. Effects of physical location of visual stimuli on intentional response time. Journal of Engineering Psychology, 1965, 4, 1-8.

The effects of physical location of visual stimuli on the IRT were investigated. Sixteen subjects performed a simple manual response to flash stimuli located at 32 different positions in the visual field. The results indicated that IRTs were unaffected for most lower visual hemisphere locations. Significant decrements were only observed for locations higher than 30° above the horizontal for lateral displacements greater than 55° from center. No significant decrements were observed even at the periphery for location along the horizontal line of sight.

282. Kohfeld, D. L. Intensity of the RT ready-signal as a determinant of adaptation level. US Army Medical Research Laboratory, Fort Knox, Kentucky, Report No. 763, 1968.

The results indicated that a 90-db ready-signal produced the slowest mean RT, 30-db the fastest, 60-db intermediate, while a random combination of ready-signals with a mean of 60-db also produced intermediate RTs. These results also held true for the subjects who were given each ready-signal condition on consecutive days. Trial to trial analyses revealed that intensity effects were stable even when ready-and response-signals intensities were presented at random within an RT session.

The ready-signal served as a reference stimulus against which the response-signals were perceived, a finding which was consistent with the implications of adaptation-level (AL) theory. There is a qualitative difference between ALs which involve a modification of sensory processes and those which can more appropriately be classified as response processes. The adaptation effects presently found belong in this latter category.

283. Kohfeld, D. L. Stimulus intensity and adaptation level as determinants of simple reaction time. Journal of Experimental Psychology, 1968, 76, 468-473.

Simple reaction time (RT) was investigated within the framework of adaptation level (AL) and stimulus intensity effects. Ss were preadapted to various levels of tonal intensity or to equally loud noise signals and given a reaction test series of tones immediately afterward. The persistence of AL effects over time was tested by giving ½ of the Ss the test series again 24 hr. later. The results were consistent with AL theory in that RT was a function of both stimulus intensity and the prevailing AL. Other results indicated that: (a) exposure to silence did not establish an effective preadaptation level, (b) the effects of preadaptation persisted for all least 24 hr., and (c) preadaptation to tone produced larger AL effects than did preadaptation to white noise.

284. Kohfeld, D. L. Effects of ready-signal intensity and intensity of the preceding response-signal on simple reaction time. American Journal of Psychology, 1969.

Forty male Ss were given a simple RT test with four ready-signal conditions, 10 Ss in each condition. A fifth group of 12 Ss received all four ready-signal condition in a counterbalanced order on consecutive days. The results indicated that a 90-db ready-signal produced the slowest mean RT, 30-db the fastest, 60-db intermediate, while a random combination of ready-signals with a mean of 60-db also produced intermediate RTs. It was concluded that the ready-signal can influence RT by serving as a reference stimulus with which the response-signal is compared. An additional analysis revealed that there were no fluctuations in RT as a function of the response-signal intensity presented on the preceding trial, a finding which suggested that trial to trial changes in the stimuli did not induce componsatory adjustments in the effective AL of the observer.

285. Konick, D. S., Morin, R. E., & Hoving, K. L. Are these two stimuli from the same set? Response times of children and adults for stimuli from familiar and arbitrary sets. Paper presented at Midwestern Psychological Association Convention, Chicago, May 1969.

286. Koplin, J. H., Fox, R., & Dozier, F. A failure to replicate the inhibitory effects of a second stimulus following the primary stimulus to react. Journal of Experimental Psychology, 1966, 72, 914-916.

Helson and Steger (1962) found that a 2nd visual stimulus exerted a retroactive inhibitory effect upon simple reaction time to a prior visual stimulus. An attempt was made to obtain this effect in 2 experiments. The 1st employed procedures similar to the original experiment, while the 2nd tested the influence of 2 procedural variables. In each case the data failed to reveal any inhibitory effect of the 2nd stimulus.

287. Kornblum, S. Response competition and/or inhibition in two-choice reaction time. Psychonomic Science, 1965, 2, 55-56.

A two-choice reaction time experiment was conducted in which it was demonstrated that the reaction time for a particular finger is subject to change depending on the alternatives with which it is paired. This finding, it is argued, raises questions regarding the adequacy of controls which select the experimental data from only one finger in an effort to minimize the effects of inter-finger variability. It is also a demonstration of R-R compatibility effects, and as such, lends experimental support to the hypothesis that a measurable portion of the reaction time interval is consumed by the processes associated with the inhibition of competing incorrect response alternatives.

288. Kornblum, S. Choice reaction time for repetitions and non-repetitions. Acta Psychologica, 1967, 27, 178-187.

The principal objective of this study was to describe some of the characteristics of the responses to repetitions and alternations in choice RT tasks. To the extent that these responses were shown to be differentially sensitive components of the overall RT, whose weighted sum yielded the linear relationship between the mean overall RT and transmitted information, it was suggested that a more detailed study of these components may be more fruitful approach toward understanding the microstructure of RT processes. Clearly these arguments are not restricted to RT tasks alone but are applicable to a wide variety of experimental results which have been described in terms of a linear relationship between information and performance measures. Our results in no way deny the descriptive statements of the information hypothesis. On the contrary, our data in fact provided one more confirmation of the hypothesis. However, we have pointed toward a possible artifactual reason for the relationship and a change or emphasis has been suggested which may lead to more explanatory types of statements than have been forthcoming from the information approach.

289. Kornblum, S. Serial-choice reaction time: Inadequacies of the information hypothesis. Science, 1968, 159, 432-434.

The results of an experiment on serial-choice reaction time, specifically designed as a critical test of the Information Hypothesis, lead to rejection of the hypothesis; information is found to be neither a necessary nor a sufficient condition to account for the data. Where previously information had been interpreted as a determinant of reaction time, it was usually confounded with the probability of nonrepetition of a signal. Thus, to the extent that this confounding is present in previous experiments, the inference attributing an increase in reaction time to an increase in information is logically invalid.

290. Kornblum, S. Sequential determinants of information processing in serial and discrete choice reaction time. Psychological Review, 1969, 76, 113-131.

It is shown that the meausre of average stimulus information (H) is confounded with the probability of nonrepetition of the stimuli in most of the experimental conditions whose results have been taken as evidence in support of the linear relationship between choice reaction time (RT) and H. The results of a serial and a discrete experiment, so designed as to unconfound these two variables, lead to a rejection of the information hypothesis. The RT for repetitions is found to be faster than for nonrepetitions, and both are decreasing linear functions of their respective conditional probabilities. Some of the discussion focuses on the manner in which the slope and the intercepts of these linear functions are affected by changes in the number of alternatives, stimulus-response compatibility, and response-to-stimulus interval. It is also shown that the present approach not only accounts for data which had previously been described by the information hypothesis, but for results which departed from the hypothesis as well. Errors are discussed in a manner which supplements the main argument. Finally, it is shown that the molar results of RT experiments can be systematically accounted for in terms of the characteristics of easily distinguishable differentially sensitive partitions in these data.

291. Kornblum, S., Burgess, J., & Siguel, E. Sequential dependencies in two-choice reaction time. Mental Health Research Institute, University of Michigan, Communication 216, 1967.

The interrelationship between the probability of a signal (p_s), the probability of alteration (p_a) or repetition (p_r), and the average signal uncertainty (H) was examined in a serial two-choice reaction time (RT) task. Twenty subjects participated in the study. Thirty-nine different stimulus sequences were used, each one consisting of 300 trials and generated by a different one-step transition matrix. The time between a response and the next signal was 270 ms. A significant decrease in the RT for alternations and repetitions was found as a function of P_a and P_r respectively. The RT for alternations showed a significant decrease as a function of P_s, whereas the RT for repetitions was not affected by P_s. Errors appeared to follow the same pattern as RT's. It is conjectured that the conditional probability of a signal may be a more parsimonious variable to account for the results of this study.

292. Kornblum, S., & Koster, W. G. The effect of signal intensity and training on simple reaction time. Acta Psychologica, 1967, 27, 71-74.

A discrepancy between data obtained by the two authors under apparently identical conditions lead to the execution of a simple experiment during the symposium. The results make it probable that a difference in stimulus intensity was the cause of the discrepency. A plea is made for the advantages of small symposia for the rapid and exciting exchange of information.

293. Kornblum, S., Reitman, J., & Siguel, E. Sequential dependencies and absolute probabilities in two-choice reaction time. Mental Health Research Institute, University of . ichigan, 1968.

294. Koster, W. G., & Bekker, J. A. M. Some experiments on refractoriness. Acta Psychologica, 1967, 27, 64-70.

When two stimuli are presented in rapid succession and a subject has either to react to both or to. the second stimulus only, the second reaction time increases with decreasing interstimulus interval. Several theories have been put forward to explain this phenomenon.

Experiments are described with which the expectancy theory and the intermittency theory can be tested. From the experimental data it is argued that the effect of expectancy is to be neglected with interstimulus intervals shorter than .6 of a second.

There appeared to be a clear discrepancy between the predicted data based on an intermittency hypothesis and the experimental data.

295. Kovac, D. Informationstheorie und die sensomotorische Reaktion. (Information theory and the sensory-motor reaction.) Zeitschrift fur Psychologie, 1965, 171, 370-376.

A survey of the current literature on reaction time shows that information theory is often applied to the stimulus pattern, but rarely to the response system. Emphasis on central factors suggests its application to both sensory and motor problems. It is suggested that the term reaction time be replaced by promptness, since its classical, quantitative meaning has shifted to qualitative aspects, currently termed processing or decision time by various writers.

296. Kristofferson, A. B. Attention in time discrimination and reaction time. National Aeronautics and Space Administration, CR 194, 1965.

A theory of attention is developed which emphasizes its temporal features. Attention is considered to be a central-neural control of information flow which is accomplished within the central nervous system. The hypothesis that it is all-or-none in nature is developed at length. The theory is framed in a sensory context and the experiments are done in that context. Alternative assumptions, which lead to different quantiatative models of the theory, are presented.

297. Kristofferson, A. B. A time constant involved in attention and neural information processing. National Aeronautics and Space Administration, CR-424, 1966.

Evidence is presented which indicates that it is reasonable to entertain the hypothesis that the human brain functions like a time-shared information processing system having a cycle time of 50 msec. A central periodic process is postulated which generates a series of equally-spaced points in time. These points, in turn, are the instants when the central processor can switch from one input channel to another and they also determine when information can be transferred from one stage within the processor to another.

Three behavioral time parameters are defined and experiments have been done which allow them to be estimated independently for single individuals. The three parameters are equal in magnitude, about 50 msec., for the group of subjects. They are highly correlated over individuals. They are independent of sensory modality. And they vary over individuals in the same way and to the same extent in relation to another variable. It is concluded that they are identical. Further, a simple theory provides an integrated interpretation of the three.

In one small experiment it is shown that the behavioral cycle time is approximately equal to the interval between zero-crossings of the alpha rhythm of the electroencephalogram and that there are significant correlations over individuals between this neuropgysiological quantity and the behavioral parameters. However, there is a discrepancy between behavioral and EEG measurements for individuals at the upper end of the scale which is sufficiently large to preclude a conclusion of identity.

298. Kristofferson, A. B. Attention and psychophysical time. Acta Psychologica, 1967, 27, 93-100.

A theory of central intermittency is proposed in which a central temporal process is assumed to control both the switching of attention between imput channels and the transfer of information between central stages. Three very different behavioral measurements are integrated by these assumptions and lead to the conclusion that the temporal process can be thought of as a succession of equally-spaced points in time occurring at a rate of approximately twenty points per second.

299. Kristofferson, A. B. Successiveness discrimination as a two-state, quantal process. Science, 1967, 158, 1337-1339.

The duration of the "psychopysical time quantum" measured through the application of a two-state model of successiveness discrimination is equal in magnitude to the alpha rhythm. The two quantities have similar distributions and they are correlated over individuals.

300. Kruup, K. The effect of complexity of interference in reaction time. Australian Psychologist, 1966, 1, 88.

RT to auditory stimulus was measured in the presence of visual interference of .04-sec duration, the latter preceding the auditory stimulus at random by 0, .1, .5, or 1 sec. The complexity of interference was manipulated by presenting the interfering light always from the same position in trials of Block A, whereas in Block B the light appeared at random in any of the 10 numbered positions on the display panel. In addition, during trials of Block C Ss were required to report the position number of each interfering light after responding. Results of 14 Ss showed significant variation of RT due to both the interval between the 2 stimuli and the complexity of the interfering stimulus. RT was the longest with the simultaneous presentation of stimuli, and L. Rubenstein's inverse relationship between the RT and the length of interval between the 2 stimuli was confirmed. Lengthening of RT as the result of complexity of interference was more pronounced when the interval between the interfering and reaction stimuli was .1 sec.

301. Kulp, R. A., & Alluisi, E. A. Effects of stimulus-response uncertainty on watchkeeping performance and choice reactions. Perception & Psychophysics, 1967, 2, 511-515.

The present study was conducted to assess the effects of S-R uncertainty on performance in watchkeeping and typical type-b choice-reaction situations. The assessment was based in part on measurements of S-R compatibility effects in the two performance conditions. Four levels of S-R uncertainty (1, 2, 3, and 4 bits/S-R event) were combined factorially with two levels of S-R compatibility (high and low) and the two kinds of tasks (watchkeeping and choice-reaction); 12 Ss were assigned at random to each of the 16 conditions. A matrix of lights was used as stimuli in the choice-reaction condition; Ss monitored the matrix for a 1-h duration in the watchkeeping condition. In both tasks Ss responded by pressing a corresponding key after the presentation of a stimulus or "critical signal." Reaction time (RT) was found to be an increasing linear function of S-R uncertainty in both task, and the effects of S-R compatibility were essentially identical in the two. However, choice reactions were significantly faster than watchkeeping responses, and the rate of gain of information in watchkeeping was greater than in the comparable choice-reaction situations. The results are interpreted as supporting the hypothesis that watchkeeping differs from the simpler choice reaction task principally in presenting an additional source of (temporal) uncertainty for information processing.

302. Kushner, E. N. Effect of motivating instructions on simple reaction time. Perceptual and Motor Skills, 1963, 17, 321-322.

Twenty-four male patients with no history of cerebral damage or psychosis and 24 non-hospitalized male Ss received 65 simple reaction time (RT) trials under constant 6-sec. foreperiod conditions. No preparatory signal was used. Time between onset of a visual stimulus and its termination by S's depression of a telegraph key was the RT. Initially, all Ss received 35 trials followed by either success, failure, or standard instructions. Thirty additional trials were given. RTs of the hospitalized Ss were longer than those of the non-hospitalized Ss, but differences fell short of statistical significance. Differences between instruction subgroups were not significant, suggesting that motivating instructions do not affect simple RT performances.

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303. LaBerge, D., & Tweedy, J. R. Presentation probability and choice time. Journal of Experimental Psychology, 1964, 68, 477-481.

The effect of stimulus presentation probability on response bias was analyzed in a 2-response color identification task. The design represented an attempt to examine a stimulus frequency component of presentation independently of the response frequency component. The 24 Ss responded with one hand to a green stimulus and with the other hand to either a red or blue stimulus. When the red and blue presentation ratios were shifted from 1:5 to 5:1 the response latencies to these colors shifted in such a way that the more frequent stimulus always yielded the faster latency. The results were interpreted as indicating that part of the effect of presentation probabilities on response bias is attributable to a pure stimulus frequency factor.

304. Lamb, J., & Kaufman, H. Information transmission with unequally likely alternatives. Perceptual and Motor Skills, 1965, 21, 255-259.

Previous investigators have concluded that the linear relation between reaction time (RT) and transmitted information found for equally likely stimuli (ELA) does not hold for unequally likely stimuli (ULA). However, the possibility still exists that a correspondence can be found by the use of a subjective probability measure. Accordingly, nine Ss were run on a choice-RT task under conditions of both ELA and ULA stimuli. The results for the ELA data confirm previous findings. The results for the ULA data not only do not support the experimental hypothesis but are completely at variance with previous results.

305. Laming, D. R. J. A statistical test of a prediction from information theory in a card-sorting situation. Quarterly Journal of Experimental Psychology, 1962, 14, 38-48.

Previous work with cards left the joint effects of varying entropy and discriminability on choice-reaction times somewhat in doubt. A card-sorting situation is here constructed in which entropy and discriminability can be varied independently. Two experiments are described with native subjects and two different treatments of the practice effect. The effect of varying entropy with discriminability held constant is shown to be significantly non-linear, contrary to the prediction from information theory. Finally a statistical model is proposed which shows at least qualitative agreement with the results of these experiments.

306. Laming, D. R. J. A new interpretation of the relation between choice-reaction time and the number of equiprobable alternatives. British Journal of Matematical and Statistical Psychology, 1966, 19, 139-149.

The interpretation of the results of Hick and Merkel in terms of Communication Theory has failed to lead to a satisfactory theory of choice-reaction times. This paper presents an alternative interpretation of the original results in terms of n parallel decisions processes, the reaction time being determined by whichever of these n decisions takes the longest. This interpretation is slightly preferable in that it gives an adequate account of the variances obtained by Hick. Some of the implications of this new interpretation are discussed.

307. Laming, D. R. J. Information theory of choice-reaction times. London: Academic Press, 1968.

308. Lappin, J. S., & Eriksen, C. W. Inhibition of a simple visual reaction time by a second stimulus: A failure to replicate. Psychonomic Science, 1964, 1, 293-294.

Helson & Steger (1962) have reported that simple reaction time to a light stimulus was increased if a second light occurred as long as 180 ms. after the primary stimulus. The present experiment was unsuccessful in producing the phenomenon. Some defects in methodology in the Helson & Steger (1962) experiment were considered.

309. Lappin, J. S., & Eriksen, C. W. Use of a delayed signal to stop a visual reaction time response. Journal of Experimental Psychology, 1966, 72, 805-811.

In a visual RT experiment, 5 male Ss were each confronted with 2 lights and instructed to respond to 1 light but not respond when both lights occurred. The onset of the 2 lights was made asynchronous by 0, 12, 33, or 63 msec. Probability of inhibiting the response declined markedly for each delay and increased with RT. It was concluded that choice RT is correlated with the extent of the stimulus information processing and the duration of effective stimulation which has preceded initiation of the motor event.

310. LeMay, R. P., & Simon, J. R. Temporal and symbolic S-R compatibility in a sequential information processing task. Journal of Experimental Psychology, 1969, 80, 558-560.

This study was concerned with speed of responding to 2 bits of information presented sequentially from a single visual display. Variables manipulated were order of presentation of the bits, coding of the bits, and interval between the bits. Ss pressed one of two buttons (labeled 0 and 1) after viewing both a "data" stimulus (0 or 1) and a "rule" stimulus (red or green). The "rule" specified whether to press the button which corresponded to the "data" stimulus or the non-corresponding button. RT was faster when the "rule" preceded the data than when the "data" preceded the rule. Corresponding responses were faster than non-corresponding responses and the 550 msec. interstimulus interval (1S1) resulted in faster responses than the 225 msec. 1S1.

311. Leonard, J. A. Advance information in sensori-motor skills. Quarterly Journal of Experimental Psychology, 1953, 5, 141-149.

Two experiments were carried out to demonstrate the effects of advance information. In both cases greater smoothness of performance was found to be possible when advance information was available. This effect was considered more important than the reduction in response time. Both effects were reflected in a reduction of the stopping times between successive responses.

312. Leonard, J. A. Partial advance information in a choice reaction task. British Journal of Psychology, 1958, 49, 89-96.

An experiment was carried out to study the effect of partial advance information on performance. Reaction time and accuracy measures were compared for three conditions: a three-choice task, and a set of experimental conditions in which a two-choice task preceded two three-choice tasks by various durations of time. Tests under all conditions were carried out after varying amounts of practice. It was found that at all stages of practice a difference between performance on the six-choice task and on the three-choice task was maintained. As the separation between the two-choice and three-choice task was varied from 0·04 sec. to 0·50 sec. in the experimental conditions, performance became increasingly similar to, and finally identical with, that under the control three-choice conditions. The relationship between duration of forewarning and performance was, however, not a simple one. The results are discussed with reference to traditional and current views on information processing.

313. Leonard, J. A. The effects of "machine" lag on a serial choice task with balance and biased input frequencies. Ergonomics, 1958, 2, 44-51.

An experiment is described which was designed to study the effects on rate or responding of (a) the frequencies of the various signals to which responses had to be made, and (b) the introduction of enforced delays between the appearance of a signal and the making of a response to it. Time taken to respond was found to be significantly lower when one of five alternative signals occurred much more frequently than others, than when the frequencies of all five signals were the same. Enforced delays in responding clearly shifted the modal response time when the input frequencies were biased.

The experiment has affinities to a number of practical tasks and was suggested by a problem arising in the sorting of letters by machine. Certain theoretical implications are also discussed regarding maximum possible rates of responding and the relation of response time to 'information'.

314. Leonard, J. A. Tactual choice reaction: I. Quarterly Journal of Experimental Psychology, 1959, 11, 76-83.

The purpose of the experiment was to observe the effect of varying the number of alternatives on choice reaction time in a task having an initial high degree of compatibility. The stimuli were presented as vibrations of relay armatures to 1, 2, 4, or 8 fingers separately, and the response was to depress the armature by the finger so stimulated. The results showed a difference between simple reaction time and two-choice times, but no systematic differences among 2, 4, or 8 choice times. The implications for further research are discussed.

315. Leonard, J. A. Choice-reaction time experiments and information theory. In Cherry, E. C. (ed.) Information Theory. London: Bullerworths, 1961

316. Leonard, J. A., Newman, R. C., & Carpenter, A. On the handling of heavy bias in a self-paced task. Quarterly Journal of Experimental Psychology, 1966, 18, 130-141.

Following an earlier observation that systematic variations in performance on a task with heavy frequency imbalance was correlated with fluctuations in the amount of bias in the input programme, an experiment was carried out to establish the roles of long and short term sampling. Two groups of subjects were trained on a self-paced, five-choice task. One group's input had an average of 68 per cent. bias on one source, the other had 44 per cent. on the same source. Analysis of data was carried out on three levels of local bias for each condition, one level being identical for both conditions. It was found that responses to the biased stimuli were determined by the average bias in each input sequence and not by moment to moment variations in that bias. The effect observed originally can therefore be accounted for in terms of a relatively simple additive model which includes the "repetition effect" first described by Bertelson.

317. Lewis, J. L. Level of processing of unattended messages. Paper presented at The meeting of the Western Psychological Association, San Diego, Calif., 1968.

Proponents of a "filter" theory of selective attention have suggested that unattended stimuli are "blocked" or "attenuated" at a relatively peripheral level. Virtually all of the evidence supporting this hypothesis has been based on the rather insensitive method of recall or a method requiring S to make an overt response to unattended stimuli, while simultaneously responding to an attended task.

A dichotic listening paradigm with simultaneous pairs of words was used in the present study. Attention was more satisfactorily controlled than in previous experiments by: (1) using a sequence of unrelated words, rather than prose with unspacifiable redundancies, (2) using a fast enough presentation rate so that S cannot switch attention back and forth between the attended message (AM) and unattended message (UM) without losing part of the AM, (3) requiring relatively errorless shadowing (repetition while listening) of the AM.

Verbal reaction time $(RT)_1$ to AM words as a function of type of UM words, was recorded. In Experiment I[1] UM words were: unrelated to AM words (U), associates to AM words (A), foreign words, (F), and taboo words (T). In Experiment II[2] UM words were synonyms (S), low (infrequent) associates (L) or high (frequent) associates (H) to AM words, and control (C) words.

The ordering of the RTs from slowest to fastest, was: A, U, F, T, (Exp. I), and S, L. H, C (Exp. II). The overall differences were significantly slower than the control words. It was concluded that the UM is processed on the basis of meaning and that a relevant UM produces more interference with processing of the AM than an irrelevant UM. Thus, even when the content of a non-shadowed message cannot be reported by S, it is not "filtered" at a peripheral level, but its meaning still affects S's behavior.

318. Lin Chung-Hsien. Some factors effecting the observation of stimuli from different directions. Acta Psychologica Sinica, 1963, 23, 113-120.

This experimental study on the observation of light signals presented in different directions resulted in: (a) Reaction time in observation was shortened greatly when Ss received a preparatory signal a few seconds before the stimulus appeared. (b) Observations accompanied with orally counting the beats of a metronome showed no influence on reaction time, which (c) increased when Ss used monocular instead of binocular vision. Reaction time and mistakes increased when Ss had the left eye blindfolded and the light was presented in the left direction and vice versa. (d) When Ss were in a supine and prone position light in a frontal, especially left-frontal, direction was very easily observed. There was no significant difference between reaction time in observing the stimuli from left and right. Stimuli in the back, especially the mid-back, region offered more difficulties. (e) Ss in a supine position discovered stimuli in the front, left and right directions more easily in the middle then in the lower region. The stimuli in the upper region seemed more difficult to observe. When Ss were in a prone position stimuli in the frontal direction were easily seen in the upper region, and also from the left and right directions in the middle region. There was no significant difference in the upper, middle, and lower regions from the back direction. (f) When Ss used monocular vision or were in a supine and prone position, stimuli in frontal direction were more easily discovered then those in the left and right direction. The most difficult stimuli to observe were those in the back region.

319. Lindsay, R. K., & Lindsay, J. M. Reaction time and serial versus parallel information processing. Journal of Experimental Psychology, 1966, 71, 294-303.

2 experiments were conducted in which Ss gave 1 or 3 responses to each stimulus in a random sequence prepared from 32 distinct stimuli which assumed 1 of 2 levels for each of 5 dimensions. The sequence was constructed so that 2 of the 32 stimuli occurred with probability 1/3 each and the remaining 30 stimuli occurred with probabilities summing to 1/3. Ss were instructed to respond by depressing a - key to one of the high frequency stimuli, and a + key to the other, and a 0 key to any of the remaining 30. Results support the hypothesis that frequently occurring stimuli may be identified as total paterns, perhaps by some sort of template matching which compares all dimensions simultaneously. However, the results also suggest that the template matches are made serially, and infrequent (or unfamiliar) stimuli are identified by a serial examination of stimulus dimensions.

320. Liu, I. Generalization and response latency. Perception & Psychophysics, 1966, 1, 366-368.

The present experiments investigated generalization in a reaction time situation where the generalization stimulus, a tone, preceded the reaction time signal, a light. The hypotheses under investigation were that the duration of the cue stimulus would determine the degree of generalization (Experiment I) and that the response latency independent of the stimulus duration would be related to the amount of generalization (Experiment II). A particular generalization test stimulus (a tone of 40, 45, 50, 60, 65, or 70 dB) was presented only once always following two bar-pressing responses to training stimulus (tone of 55 dB) under each of two conditions of stimulus duration in Experiment I and under each of two conditions of response latency in Experiment II. It was found that under the condition of short response latency generalization was broader.

321. Liu, I. Response latency depends on response speed. Japanese Psychological Research, 1968, 10, 174-178.

322. Liu, I., & Kuo, S. Initial improvement in simple reaction time. Journal of Experimental Psychology, 1968, 78, 593-598.

In order to study the factors responsible for the improvement occurring in the initial few trials of a simple reaction time (RT) task, 9 experimental groups of 20 Ss each had 3 kinds (hearing alone, pressing alone, and responding to a light) and three degrees (1, 3, and 10 trials) of pretraining. A control group of 20 Ss was given 0 amount of pretraining. In the subsequent simple RT task, Ss had to press a key on hearing a tone. It was found that the groups that received 3 and 10 hearing alone pretraining trials started with shorter mean RTs and then took about the same number of trials to reach the performance asymptote (compared with the control group) and that the groups given 3 and 10 pretraining trials of responding to the light reached the asymptote on the 2nd trial. The results pointed to the operation of 2 processes: information-checking mechanism and acquisition of responding to stimulus onset.

323. Locke, E. A. Effects of knowledge of results, feedback in relation to standards, and goals on reaction time performance. The American Journal of Psychology, 1968, 81, 566-574.

Seven groups of 10 Ss each were given 40 trials on a visual reaction-time task. The experimental groups were given different amounts of knowledge of results (KR), and they set or were assigned different performance-goals. Partial correlations revealed that it was the Ss' goal-levels rather than the amount of KR they received that governed performance on the task.

324. Loveless, N. E., & Holding, D. H. Reaction time on tracking ability. Perceptual and Motor Skills, 1959, 9, 134.

325. Luce, R. D. Response latencies and probabilities. In Arrow, K. J., Karlin, S. and Suppes, P. (ed.) Mathematical Methods in the Social Sciences, Stanford: Stanford University Press, 1959.

326. Luschei, E., Saslow, C., & Glickstein, M. Muscle potentials in reaction time. Experimental Neurology, 1967, 18, 429-442.

Seven human and four monkey Ss performed a reaction time task at short latency following sound or light stimuli. EMG potentials were recorded in the responding limb during performance. The EMG latency was analyzed by study of individually recorded traces and computer averaging. Two classes of EMG activity were observed. One class strongly correlated with the response. In human Ss response-correlated activation of biceps occurred 80 msec. after an auditory stimulus and 125 msec. after a light stimulus. Slightly longer latencies were recorded for response-correlated activity in monkeys. The 2nd class was unexpected. Early EMG activity was seen in responding muscles much before the response-correlated potentials and appeared to be more closely linked to the sensory stimuli than to the response. Such early potentials were seen at latencies as brief as 25-50 msec. after the stimulus in the arms of monkey Ss and were observed in extensor digitorum communis of 1 human S when intramuscular recording electrodes were used.

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327. Marill, T. The psychological refractory phase. British Journal of Psychology. 1957, 48, 93-97.

A reaction-time experiment was performed in which S was presented with two lights and two hand keys. A flash of the left light served as a stimulus to press the left key with the left hand; the right light to press the right key with the right hand. Trials were given in which both lights flashed; the interval between flashes being randomly selected from none possible values ranging from 0 to 600 msec., the various intervals occurring with equal probability.

If S_1 and S_2 are the prior and subsequent of a pair of stimuli calling forth responses r_1 and r_2, respectively, it was found: (a) that presenting s_2 during the s_1,-r_1 interval has no systematic effect on this interval; (b) that the s_2-r_2 interval varies markedly as a function of the s_1-s_2 interval, with s_2-r_2 longest for short s_1s_2.

328. Marshall, M. E. Some effects of amount of verbal pretraining and availability of verbal labels upon performance in a discriminative motor task. Perceptual and Motor Skills., 1968, 26, 27-39.

Adult Ss were given either 3, 6, 9, 15, or 30 trials of relevant or irrelevant verbal pretraining prior to 21 trials on a common discriminative motor task. Relevant pretraining facilitated motor performance significantly over-all, and increasing amounts of relevant pretraining significantly increased the amount of specific proactive facilitation. Within relevant pretraining conditions, significantly superior motor performance was related to the subsequent correct recall of verbal pretraining responses. Methodological problems and theoretical implications are discussed.

329. May, M. J. Sensitive reaction time switches. Perceptual and Motor Skills, 1964, 18, 360.

330. May, M. J. A new method for studying visual latency. Vision Research, 1964, 4, 515-516.

When reaction time is used as a dependent variable in the study of stimulus effects upon the organism, as for example the effect of light intensity on latency to perception, one assumes a linearity between latency changes in the perceptual domain and corresponding changes in the motor response. However, because of the many factors which affect the motor response, e.g. training, anticipation and other subject-induced variables, or the type of response-measuring devices and other experimenter-induced variables, this assumption is questionable. Therefore, in studies concerned with sensory or perceptual latencies, it would be advantageous to eliminate the motor phase in the dependent variable and instead to use a measure more closely identified with the perceptual changes.

The most recent psychophysical methods for measuring visual latency are that of LIT (1949), who calculated perceptual latencies from measures found by studying the Pulfrich Sterophenomenon, and ROUFS (1963), who used a two-flash method utilizing apparent movement and the classical reaction-time method to study perceptual latencies and compared the values found with each method. The present method is in the older psychophysical tradition and can be thought of as a temporal Pulfrich-type phenomenon.

331. May, M. J. The psychological refractory period as measured by eye-movement latencies to visual signals presented in sequence. Dissertation Abstracts, 1965, 26, 505.

The psychological refractory period was tested by three experimental conditions. In each of these conditions complex visual signals were presented in pairs. The interval between the first and second signal was varied and covered a range of from 0 to 1000 msec. Four Ss were used.

In the first experiment Ss were required to made a correct response to each stimulus as rapidly as possible. In the second experiment Ss were required to respond only to one specific danger signal while attempting to avoid responding to irrelevant stimuli. In the third experiment Ss responded as soon as the information contained in each signal was recognized.

It was found that the refractory period is not simply related to the length of time required to respond to the first signal in the pair, but rather that it is dependent on the stimulus complexity and the response requirements. For the tasks involved in this study the refractory period varied from 560 msec. for the first experimental condition to 400 msec. for the third experimental condition.

A hypothetical description is given of the sequence in which the various steps of the response to each signal is made.

332. McCormack, P. D., & Bell, C. L. A serial simple reaction-time circuit. Perceptual and Motor Skills, 1963, 16, 415-416.

A description of a simple reaction time circuit which eliminates the recording of anticipatory responses as non-anticipatory in nature and yet preserves the integrity of the interval of time between the response and the onset of the signal.

333. Mc Cormack, P. D., Binding, F. R. S., & Chylinski, J. Effects on reaction time of knowledge of results of performance. Perceptual and Motor Skills, 1962, 14, 367-372.

Two experiments were performed, each with the purpose of assessing the effects on reaction-time of knowledge of results of performance. In both, S's task was to depress a switch as fast as possible in response to the presentation of a light which appeared on the average once per minute with the intervals between lights being 30, 45, 60, 75, and 90 sec. In the first study, 20 Ss participated for 35 min. on each of two consecutive days. On one of these days knowledge of results was provided while on the other it was withheld. Under the knowledge treatment a red or a green light was illuminated immediately following each response. The former indicated a reaction-time which was slower than the previous one while the latter signalled a faster response. These lights were not employed under the no-knowledge condition. Twenty additional Ss served in a single 35-min. session under a second no-knowledge condition in which the two lights were presented simultaneously following the elicitation of a response. In the second study, 24 Ss participated for 35 min. on each of three consecutive days under the knowledge and two no-knowledge conditions of Exp. I. For both of the no-knowledge treatments, reaction-time increased with time on task and decreased with length of interstimulus interval. Under the knowledge condition, however, performance remained invariant with respect to both task duration and interval length.

334. Mc Cormack, P. D., Binding, F. R. S., & McElheran, W. G. Effects on reaction time of partial knowledge of results of performance. Perceptual and Motor Skills, 1963, 17, 279-281.

Five groups of male Ss participated in a reaction time experiment under 0, 30, 50, 70, and 100% knowledge of results conditions. The only dependable change in reaction time with times became longer with increased task duration.

335. Mc Cormack, P. D., & Mc Elheran, W. G. Follow-up of effects on reaction time with partial knowledge of results. Perceptual and Motor Skills, 1963, 17, 565-566.

Five groups of Ss participated in a reaction time experiment under 0, 10, 20, 30, and 40% knowledge of results conditions. The only dependable changes in reaction time with time on task were observed for the 0, 10, and 20% groups where reaction times became longer with increased task duration.

336. Mc Cormack, P. D., & Prysiazniuk, A. W. Reaction time and regularity of inter-stimulus interval. Perceptual and Motor Skills, 1961, 13, 15-18.

Twenty-four Ss were required to depress a switch as fast as possible in response to the presentation of a light. All participated for 35 min. on each of three consecutive days. During these sessions the light appeared on the average once per min. but the degree of regularity with which it was presented differed from day to day. In Condition I it appeared at regular 60-sec. intervals. In Condition II the intervals between stimuli were 30, 45, 60, 75, and 90 sec., while in Condition III the stimuli were separated by 10-, 35-, 60-, 85-, and 110-sec. intervals. Reaction-times increased with time on task, decreased with the degree of regularity with which the light was presented and remained invariant with length of inter-stimulus interval. The slope of the function relating reaction-time to task duration was the same for all three conditions but discrepancy were enumerated. The findings of the present study, as well as those of earlier investigations, are consistent with the hypothesis that inhibition accumulates linearly with time and dissipates during periods of interpolated rest. Experimental manipulations of knowledge of results and degree of regularity of inter-stimulus interval are tentatively assumed to affect S's motivational level.

337. Mc Cormack, P. D., & Wright, N. M. The positive skew observed in reaction time distributions. Canadian Journal of Psychology, 1964, 18, 43-51.

The hypothesis presuming that the long latencies observed in simple reaction time situations are due to anticipatory responses, is investigated. 5 male Ss participated, each for approximately 30 min., in an experiment during which the electromyographic potential of the right arm flexor muscles was recorded. 2 types of activities were observed: one was of an anticipatory nature, the other was characterized by a muscular movement which occurred after the beginning of the stimulus, but which did not have sufficient amplitude to turn of the stimulus. The 2nd type of activity was found more clearly related to long latency than the first. 4 ancillary studies showed the same phenomena occurring in sessions subsequent to the first, and under conditions where the types of instructions, the method of presenting the stimulus, as well as certain important aspects of the switches were varied. The findings were related to the notion of approach-avoidance gradients.

338. Mc Gill, W. J., & Gibbon, J. The general-gamma distribution and reaction times. Journal Mathematical Psychology, 1965, 2, 1-18.

The general-gamma distribution describes input-output times in a multistage process consisting of exponential components whose constants are all different. The distribution and its unique history are examined. A stochastic process that leads to it is presented. The conditional density (hazard) function is studied as a means for estimating parameters. The multistage process model is applied to simple reaction times in an effort to reveal underlying detection and response components.

339. Medeiros, R. R., White, R. K., & Ayoub, M. M. The effect of light and sound variables on reaction time. Journal of Engineering Psychology, 1965, 4, 9-21.

Simple reaction time was measured for 8 college males at various combinations of light level, noise level, stimulus intensity, and shade of background to see if the interaction of theses variables would significantly affect RT. Ten trials were taken at each treatment conditions. Trial 1 was significantly longer than the remaining nine trials. The effect of stimulus intensity was highly significant with more intense stimulus causing the longer RT. At low levels of light with the grey background, subject adaptation was similar to that of the black backgrounds; at high levels of light with the same background, adaptation was similar to the white background. Noise levels and light levels interacted, suggesting that three phases of intersensory interaction between sound and vision receptors exist. The results of the experiment demonstrates the need to more adequately record light and noise on various threholds of light, expecially the pain threshold and vice-versa.

340. Mehler, J., & Carey, P. The interaction of veracity and syntax in the processing of sentences. Perception & Psychophysics, 1968, 3, 109-111.

The reaction times of 80 Ss in judging sentences true or false with respect to pictures were analyzed, and it was noted (a) that true sentences containing an expected surface structure required less time than false sentences of the same structure, (b) that latencies to true sentences containing an unexpected surface structure were longer than latencies to the same sentences when their structure was identical to that of previous sentences, and (c) that transitive-verb constructions appeared easier to judge than predicate nominatives of the same length.

341. Michon, J. A., & Van Der Valk, N. J. L. A dynamic model of timing behavior. Acta Psychologica, 1967, 27, 204-212.

Studies of tapping behavior have failed to incorporate the sequential aspects of the performance of subjects. A methodological frame (generating functions) and a model (a dynamic linear system with two parameters) are proposed to improve our descriptive and predictive power. An experimental evaluation of this model is given and shows a fairly good fit to stepwise changes in the rate of tapping: the model accounts for between 70 and 98% of the explainable variance in the data.

One of the two parameters of the model appears to be a personal parameter, the other is a function of the average interval length, and therefore highlights the limitations of the linearity assumptions.

Some possibilities of further application of the method are discussed.

342. Minucci, P. K., & Connors, M. M. Reaction time under three viewing conditions: Binocular, dominant eye, and nondominant eye. Journal of Experimental Psychology, 1964, 67, 268-275.

Reaction times for 10 Os were measured at 4 photopic intensity levels: 7.13, 8.06, 9.10, and 10.18 log uuL., under binocular, dominant eye, and nondominant eye viewing conditions. Reaction time has been found to be a negatively accelerated, decreasing function of increased light intensity. There is a constant relationship between the binocular reaction time and the average monocular reaction time for each O. Equivalent brightnesses under each viewing condition were calculated on the basis of speed of reaction. The resulting curves suggest that binocular reaction times are faster than would be expected from the data of the dominant and the nondominant and the nondominant eye, even assuming complete summation.

343. Moray, N. Where is the capacity limited? A survey and a model. Acta Psychologica, 1967, 27, 84-92.

A model is presented for the limitations of processing information by the human operator which proposes that he acts not as a limited capacity channel with fixed capacity, but as a limited capacity processor. The total capacity of the brain can be allocated to the separate aspects of the tasks, such as reception, recoding, emission, storing, etc. Hence from moment to moment the size of the 'channel' in the Shannon sense will appear to vary. In particular parallel processing is possible where the total capacity is not exceeded, and where there is high compatibility. Experimental evidence in support of the model is presented.

344. Morgan, B. B., & Alluisi, E. A. Effects of discriminability and irrelevant information on absolute judgments. Perception & Psychophysics, 1967, 2, 54-58.

The effects of irrelevant information (0, 1, 2, or 3 bits/stimulus) on absolute judgments of size were measured at different levels of discrimination difficulty. The stimuli were 7 small circular spots of light of different sizes, selected from an equal-discriminability scale, and arranged into 6 pairs that represented different levels of stimulus dissimilarity (LD) subgrouping in which different levels of dissimilarity and discriminability were confounded, whereas the remaining three pairs comprised a high-dissimilarity occurred at a single high level of discriminability. Different colors were used to provide the four levels of irrelevant information; 240 Ss (10 in each of the 24 experimental conditions) made absolute judgments of size under the classical procedure for the method of single stimuli. Separate analyses of errors, reaction times, and rates of information transmission indicated that irrelevant inforamtion had an increasingly detrimental effect on absolute judgments as discrimination difficulty was increased (in the LD subgroup), but essentially no effect where discriminations were easily made (in the HD subgroup).

345. Morgan, C. T., Cook, J. S. III, Chapanis, A., & Lund, M. W. (eds.) Human Engineering Guide To Equipment Design, New York; MC Graw-Hill Book Company, Inc., 1963.

346. Morin, R. E., & Forrin, B. Mixing of two types of S-R associations in a choice reaction time task. Journal of Experimental Psychology, 1962, 64, 137-141.

Two types of S-R associations were distinguished in terms of behavioral criteria. Type N associations (e. g., numeral-numeral pairs) normally produce independence of choice RT and transmitted information. For Type D associations (e. g., symbol-numeral pairs) choice RT is a positive linear function of transmitted information. The present study investigated the effects of mixing Type N and Type D associations upon the RT-transmitted information function.

Ten male Ss were randomly assigned to each of five experimental conditions defined by the character of the the S-R set: (1) two Type N pairs, (II) two Type D pairs, (III) two Type N and two Type D pairs, (IV) four Type N pairs, and (V) four Type D pairs. Analyses examined the reactions to the two critical Type N pairs common to Cond. I, III, and IV (Exp. A) and to the two critical Type D pairs common to Cond. II, III, and V (Exp. B). In Exp. A, mean RT to the critical Type N pairs was not degraded by the expansion of the S-R set from two to four Type N pairs (Cond. I vs. Cond. IV); in contrast, mean RT was increased significantly by the addition of two Type D pairs (Cond. I vs. Cond. III). In Exp. B, response latencies to the critical Type D pairs were shortest in Cond. II. The addition of two type N pairs to the S-R set (Cond. III) lengthened mean RT to the critical Type D pairs by an amount comparable to that obtained by the addition of two Type D pairs (Cond. V).

The results of this study were considered to limit the generality of the proposition that RT for numeral-numeral associations is independent of the informational properties of the task.

347. Morin, R. E., & Forrin, B. Response equivacation and reaction time. Journal of Experimental Psychology, 1963, 66, 30-36.

This study was designed to assess the relative contributions of transmitted and response information to choice reaction time (RT) in a task involving a 1-many mapping of stimuli into responses. 35 Ss served in 5 independent conditions which varied in terms of number of stimuli displayed (2 or 4) and number of responses per stimulus (1, 2, or 4). In conditions with more than 1 response per stimulus, Ss were instructed to select randomly from available correct response alternatives; this procedure effected a partial unconfounding of response and transmitted information. Ss were given 576 RT trials distributed over 3 days of practice. Differences in RT between conditions were more clearly associated with differences in response uncertainty than with differences in amount of information transmitted.

348. Morin, R. E., & Forrin, B. Information-processing: Choice reaction times of first- and third- grade students for two types of associations. Child Development, 1965, 36, 713-720.

The primary intent of the study was to investigate the effect of amount of prior experience upon the slope of the function relating choice reaction time (RT) to stimulus uncertainty. This aim was implemented by comparing the performance of first- and third-grade students on a numeral naming task with size of stimulus set varied. Although reaction latencies for third-grade students were significantly shorter than those for first-grade students, for neither group was an increase in the amount of information per numeral associated with an increase in choice RT. An explanation of the latter result in terms of the absence of response competition for numeral-numeral associations is examined.

349. Morin, R. E., Forrin, B., & Archer, W. Inforamtion processing: The role of irrelevant stimulus information. Journal of Experimental Psychology, 1961, 61, 89-96.

The present experiment was designed to investigate the effects of irrelevant stimulus information upon information processing behavior in a disjuctive reaction time (RT) task. Ten Ss were assigned to each of five conditions defined by the number of equiprobable stimulus events presented and by the number of correct response alternatives available. In three conditions the amount to stimulus information (0, 1, or 2 bits) and the amount of response information were equated. In two conditions stimulus uncertainty (2 bits) exceeded response uncertainty (1 bit). Though identical with respect to information measures the latter conditions differed in terms of the perceptual demands placed upon S.

The presence of irrelevant stimulus information did not significantly influence the rate of information processing at advanced levels of performance. This result was found to hold when (a) both relevant and irrelevant stimulus dimensions were presented to the same modality and in spatio-temporal contiguity, and (b) the character of the discrimination task required that S attend to all salient features of the stimulus display. On the basis of these findings it was suggested that the linear relation between stimulus information and RT observed by Hyman, and replicated in the present study, can be attributed to the confounding of stimulus, response, and transmitted information. In addition, the data provided some support for Bricker's contention that the rate of information processing is more closely associated with the amount of information transmitted than with response uncertainty.

350. Morin, R. E., & Grant, D. A. Learning and performance on a key pressing task as a function of the degree of spatial S-R correspondence. Journal of Experimental Psychology, 1955, 49, 39-47.

Eighty-one Ss in nine groups practiced keypressing responses to light stimuli under nine different degrees of spatial stimulus-response correspondence between lights and keys. The degree of correspondence was specified by Kendall's τ, a measure of rank correlation. The basic findings were:

1. Performance was uniformly superior when keys and stimuli lights were in direct correspondence (τ =1.00).

2. The marked degradation of performance in other conditions proved to be related to τ by regular and rather simple functions. The function relating mean time per pattern to τ had significant linear and quadratic components. These were hypothesized to be related, respectively, to factors defined by the algebraic and absolute values of τ.

3. Scaling of correspondence by τ provided a set of homogeneous psychomotor tasks of scaled difficulty with an initial difficulty range in time scores of five to one and a final range of three to one.

4. Nondirect correspondence groups showed a high dependence on a set of response information feedback lights.

5. In a final test in which all groups transferred to direct correspondence practice, facilitation rather than interference was found.

351. Morin, R. E., Konick, A., Troxell, N., & McPherson, S. Information and reaction time for "naming" responses. Journal of Experimental Psychology, 1965, 70, 309-314.

The relationship between stimulus information (1, 2, or 3 bits) and reaction time (RT) was investigated for 5 types of associations all of which required naming responses to familiar stimuli (Experiment II--line drawings of animals; Experiment III--colors; Experiment IV--geometric symbols; Experiment V--letters of the Alphabet). Each of 54 Ss served in 3 information conditions of 1 of 5 experiments. The observed slope for letters, though reliable, was less than .01 sec/bit. In Experiments I-IV marked increases in RT accompanied changes in stimulus information, and all curves were negatively accelerated. The results indicate that a high degree of overlearning is not sufficient to produce independence of RT and information measures. A response-competition hypothesis is suggested to account for differences between the results with letters and other stimuli.

352. Morrell, L. K. Intersensory facilitation of reaction time. Psychonomic Science, 1967, 8, 77-78.

Human reaction times (RTs) to a photic stimulus were found to be shortened by an after-coming auditory stimulus. The effect was linearly related to interstimulus interval; the observed range was 20-120 ms. Faster RTs were found for shorter intervals.

353. Morrell, L. K. Temporal characteristics of sensory interaction in choice reaction times. Journal of Experimental Psychology, 1968, 77, 14-18.

Reaction times (RTs) to a photic stimulus were evaluated as a function of the interval between a flash and a click which followed at varying intervals (ranging 20-120 msec.) in a choice RT task. RT to flash was found to be a linear function of the interstimulus interval between the flash and the click. The shorter the interval, the faster the RT. With choice RT, mean responses to flash-click pairs separated by as much as 120 msec. were reliably faster than those obtained to flash presented alone.

354. Morrell, L. K. Cross-modality effects upon choice reaction time. Psychonomic Science, 1968, 11, 129-130.

Facilitation of reaction time by a second stimulus in another sense modality than the initial signal for response extended over a longer range of interstimulus intervals when the presented sequence was visual-auditory as compared with auditory-visual. The expected difference between visual and auditory reaction times was diminished or eliminated with paired bi-modal stimuli.

355. Moss, S. M. Simple reaction time and response sets. Human Factors, 1966, 8, 239-243.

This study was concerned with the effects of induced response inhibition on simple visual reaction time. Ten Ss were confronted with up to four response alternatives (fingers of the right hand), one of which was the required response. Each of these responses was associated with a specific stimulus. Three response ensemble conditions were used: I--within a block of trials only one light appeared, II--within a block of trials one of two possible lights appeared, III--within a block of trials one of the four possible lights appeared. Under all conditions Ss were given more than adequate time to extract the appropriate response from the remaining responses in the ensemble prior to the time that they were required to make the response. A significant interaction was found between the individual responses and response ensembles. These results were explained in terms of the contextual effects of the unused responses within the different ensemble conditions. Additional data indicated that these effects reflect a spatial relationship to responses being measured. Unused responses that are more proximal to the measured response depress the reactions to that response as compared to unused responses that are more distant.

356. Moss, S. M. Changes in preparatory set as a function of event and time uncertainty. Journal of Experimental Psychology, 1969, 80, 150-155.

Choice reaction times (RTs) to two equally probable events were measured under conditions where, within a block of trials, one of the events (fixed) occurred with a constant foreperiod and the remaining event (variable) occurred with a uniform distribution of foreperiods. Changes in preparatory set to the variable event were produced when the foreperiod of the fixed event was systematically manipulated within the distribution of variable event foreperiods. Prior to the interval of the fixed event foreperiod Ss attend to the fixed event. After this duration has lapsed Ss predict with greater accuracy the onset of the variable event. When the variable event occurs at the same foreperiod as the accompanying fixed event, Ss switch their attention to this event. This switch was found to be independent of the probabilities associated with the variable event as indicated by the almost invariant RTs to this event across the fixed event conditions.

357. Moss, S. M., Engel, S., & Faberman, D. Alternation and repetition reaction times under three schedules of event sequencing. Psychonomic Science, 1967, 9, 557-558.

Choice RTs to two equally frequent events were measured under three event alternation-repetition ratios: 3:1, 1:1 and 1:3. The Rts to alternating events were found to be faster than to repeating events under the 3:1 condition, with this effect decreasing as the degree of repetition increased. Averaged RTs under each of the conditions indicated that Ss responded faster under the remaining two conditions. These results are discussed in terms of the subjective event probabilities under the three alternation-repetition ratios.

358. Mowbray, G. H. Choice reaction times for skilled responses. Quarterly Journal of Experimental Psychology, 1960, 12, 193-202.

Two kinds of choice reaction time experiments are reported, both of which make use of a highly overlearned sensori-motor response. When a response is required for each stimulus presented, no increase in reaction time occurs as a function of the number of alternative stimuli available. It is proposed that the increase in choice reaction time commonly thought to accompany an increase in the number of alternatives choices provided reflects the unpractised state of the responder. When a response is required for only one out of n possible stimuli, a slight but consistent increase in reaction time takes place with an increase in the number of alternatives. An analogy is drawn between the second experiment and a vigilance task and an expectancy hypothesis is invoked to explain the results.

359. Mowbray, G. H. Some remarks concerning Brebner and Gordon's paper "Ensemble size and selective response times with a constant signal rate." Quarterly Journal of Experimental Psychology, 1962, 14, 117-118.

360. Mowbray, G. H. Subjective expectancy and choice reaction times. Quarterly Journal of Experimental Psychology, 1964, 16, 216-223.

Previous findings suggested that selective response times might be affected both by the inter-stimulus interval and by the probability of occurrence of the stimulus for reaction. These two factors have been tested independently and have been found to influence reaction times in a fashion that an expectancy hypothesis would predict.

361. Mowbray, G. H., & Rhoades, M. V. On the reduction of choice reaction times with practice. Quarterly Journal of Experimental Psychology, 1959, 11, 16-23.

Information theory concepts have been discussed in relation to data from choice reaction time experiments. Specifically, it has been stated that choice reaction time is proportional to the logarithm of the number of randomly appearing alternative stimuli. It is suggested that the reported increase in choice reaction times with an increased number of alternatives is the result of insufficient practice. Data are provided to show that, with sufficient practice, this increase does not occur between two and four choices.

362. Moyer, R. S., & Landauer, T. K. Time required for judgments of numerical inequality. Nature, 1967, 215, 1519-1520.

Explored the nature of the process involved in adults' choice of a larger number by examining the time which the process requires. Stimuli consisted of 2 1-digit numbers 2.5 cm. apart on a white background. Ss threw the left of right of 2 switches depending on the placement of the larger number. Results showed that "decision time was an approximately linear inverse function of the numerical differences between the 2 stimulus digits." It is suggested that this process is analogous to the process involved in judgments of inequality for physical continua.

363. Murray, H. G., & Kohfeld, D. L. Role of adaptation level in stimulus intensity dynamism. Psychonomic Science, 1965, 3, 439-440.

Thirty female college students were first adapted to either a 40 db tone, a 100 db tone, or to silence (N=10), then given 48 reaction time (RT) trials with randomly ordered presentations of 40, 60, 80, and 100 db auditory signals. RT at all levels of signal intensity was fastest for Ss adapted at 40 db, slowest for Ss adapted at 100 db, and intermediate for Ss adapted to silence. These findings are predicted by Helson's adaptation-level theory but not by Hullian theory.

364. Mylrea, K. C. A sixteen-unit projector with micro-second turn-on time. American Journal of Psychology, 1966, 79, 314-317.

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365. Naatanen, R. On the interrelations between the fore period and the reaction time in simple reaction experiments. Reports from the Psychological Institute, University of Helsinki, 1963, No. 1.

The Retardation Hypothesis can be used to explain the effect of the fore period on the RT within the limits of the experiments carried out in this study, regardless of whether a constant fore period is used or several fore periods are used randomized in the same series. In addition, the arguments against the parallel hypothesis, the Exhaustion Hypothesis, seen to be sufficient. Also, the results obtained by Woodrow, Telford, Klemmer, and Karlin are explicable through the Retardation Hypothesis.

366. Naatanen, R. An explanation for the longest reaction times obtained by using the shortest fore periods of a randomized fore period series. Reports from the Psychological Institute, University of Helsinki, 1967, No. 4.

Describes why the shortest fore periods in a randomized series composed of fore periods of different durations usually yield the longest RTs, whereas they yield the fastest RTs in experiments in which the fore period of each duration is repeatedly presented. A possible explanation is based on the changing probabilities of the delivery of the stimulus at each possible moment as the time following the warning signal passes in experiments conducted with randomized fore periods of different durations. Results with 13 19-34 yr. old Ss indicate that when the change of probabilities is eliminated, the shortest fore periods in the series no longer yield the longest RTs. It is concluded that the main reason for the diverging tendencies is the information-generating character of the passage of time following the warning signal RT experiments with randomized fore periods of different durations.

367. Nicholson, R. M. Maximum information-handling rates for sequentially presented visual stimuli. Human Factors, 1962, 4, 367-373.

The purposes of this study were: (1) To determine information-handling rates for sequentially presented stimuli; (2) demonstrate the relationship between information-handling rate and size of the surface that the operator must monitor, and (3) determine the effect of variations in duration of stimulus exposure. Performance measures were obtained for thirty subjects on three different panel sizes at two different exposures. Two methods were used in obtaining data: a method of sequentially varied stimuli and a method of randomly varied stimuli.

All performance cures indicate a monotonic decrease as the speed of presentation was increased. Speed of presentation and the interaction of speed of presentation and panel size were determined to be significant at the 0.005 and 0.05 levels, respectively. The effect of the exposure times variable was nonsignificant.

The method of randomly presented stimuli resulted in significantly better performance than the method of sequentially varied stimuli.

368. Nickerson, R. S. Response times for "same" -- "different" judgements. Perceptual and Motor Skills, 1965, 20, 15-18.

S's task was to decide as quickly as possible whether the second of two visually presented English consonants was the same as the first. RTs associated with the decision "same" tended to be shorter than those associated with the decision "different."

369. Nickerson, R. S. Response time to the second of two successive signals as a function of absolute and relative duration of intersignal interval. Perceptual and Motor Skills, 1965, 21, 3-10.

An experiment was conducted to determine whether both the absolute and the relative duration of the S_1--S_2 interval would affect the response time to the second of two successive signals (RT_2) separated by an interval of brief but variable duration. Four different experimental conditions sampled different but overlapping ranges of intervals, thus allowing comparisons between RTs obtained with intervals of the same absolute but different relative durations, and conversely, with the same relative but different absolute durations. Under these conditions, RT_2 varied inversely with both the absolute and the relative duration of interval over the range of intervals generally associated with psychological refractory period.

370. Nickerson, R. S. Adams' bisensory discrete tracking task and the psychological refractory period: A comment. Psychonomic Science, 1965, 3, 87-88.

Adams (1962) has reported an experiment designed to test the "single channel" interpretation of the "psychological refractory period" (PRP). The purpose of the note is to challenge the validity of the test and to argue that the results of the experiment are compatible with a "single channel" hypothesis.

371. Nickerson, R. S. Response times with a memory-dependent decision task. Journal of Experimental Psychology, 1966, 72, 761-769.

4 experiments were conducted to determine the time required to make some simple memory-dependent decisions. S's task was to decide whether any of the items of a memorized check list were contained in a visually displayed search list, and to register his decision as quickly as possible by pressing 1 of 2 response keys. RT varied directly both with the number of items in the check list and the number in the search list, and inversely with the number of items common to both lists. Practice reduced RT across conditions, and it also decreased, but did not eliminate, the effects of the independent variables. Decreases in RT with practice were accompanied, in most cases, with increases in the frequency of errors.

372. Nickerson, R. S. Expectancy, waiting time and the psychological refractory period. Acta Psychologica, 1967, 27, 23-34.

The problem of the expectancy for the second of two variably spaced signals growing with the waiting time following the occurrence of the first signal was considered. An experimental procedure which makes waiting time noninformative was described. Data from two experiments were presented which suggest that the procedure may have been effective in stabilizing psychological expectancy over waiting time. Nevertheless, RT to the second of two signals varied inversely with the duration of the interval between signals, for intervals up to approximately 250 msec. Minimal RTs were not consistently associated with the most frequent, median or mean interval durations. Independently of interval duration, RT tended to vary inversely with the 'momentary' probability of signal occurrence.

373. Nickerson, R. S. Categorization time with categories defined by disjunctions and conjunctions of stimulus attributes. Journal of Experimental Psychology, 1967, 73, 211-219.

Ss were asked to decide as quickly as possible whether stimuli belonged to categories defined in terms of conjunctions or inclusive disjunctions of readily discriminated attributes, and to register their decisions by pressing 1 of 2 response keys. The independent variables of interest were the number of attributes which were relevant to a category criterion (r), and the number of attributes with respect to which a stimulus satisfied (s), or failed to satisfy (f), a criterion. It was found (a) that with disjunctive criteria positive RT varied directly with r and inversely with s, (b) that the latter effect persisted after considerable practice, (c) that with conjunctive criteria negative RT varied inversely with f, (d) that this effect also persisted with practice, (e) that negative instance of disjunctive categories and positive instances of conjunctive categories produced shorter RTs than would have been expected from an extrapolation of the results with positive and negative instances of disjunctive and conjunctive categories, respectively, (f) that with both disjunctive and conjunctive criteria error rates were highest under those conditions in which RT was longest. Implications of the results for the question of sequential vs. parallel information processing modes were considered.

374. Nickerson, R. S. Psychological refractory phase and the functional significance of signals. Journal of Experimental Psychology, 1967, 73, 303-312.

6 experiments were conducted to investigate the effects of the functional, or informational, significance of signals on the "psychological refractory phase." In brief, it was found that the response to the 2nd of 2 successive, but variably spaced, signals was delayed when the interval between signals was sufficiently brief, whether or not an overt motor response had to be made to the 1st signal, and whether or not the 1st signal carried information which was critical to the performance of the task. The magnitude of the delays obtained depended both on the functional significance of the signals and on the motor requirements of the task. The implications of these and ancillary findings for "single channel" and "expectancy" theories of psychological refractory phase were discussed.

375. Nickerson, R. S. "Same"-"Different" response times with multi-attribute stimulus differences. Perceptual and Motor Skills, 1967, 24, 543-554.

S's task was to decide as quickly as possible whether two simple visual stimuli were the same or different. Stimuli varied with respect to 3 attributes: size, color, and shape. Pairs of stimuli were presented either simultaneously or in sequence. "Different" RTs varied inversely with the number of attributes with respect to which the 2 stimuli of a pair differed, $\underline{d}$. "Same" RTs were shorter than would be expected from an extrapolation of the results with $d \geq 1$ (different stimuli) to include the case of $\underline{d}=0$ (same stimuli). Error rates were related to $\underline{d}$ in much the same way as was RT.

376. Nickerson, R. S. "Same"-"Different" response times: A model and a preliminary test. Cambridge, Mass: Bolt Beranek and Newman Inc. Report No. 1729, 1968.

Based on previous work by Stone (1960), McGill (1963), Sekuler (1965), and Bindra, Williams and Wise (1965), a model is presented for predicting the results to be expected when subjects are required to decide whether two successively presented stimuli are the same or different. The model assumes a "counter" for cumulating "difference" information, and a "clock" for keeping time. The subject sets both a count criterion and a time criterion in accordance with stimulus and payoff parameters. The decision rule is: if the count criterion is exceeded before the time criterion, decide "different," otherwise decide "same." The results of a preliminary experiment are presented in which an attempt was made to test some of the model's implications with respect to the relationships between response times associated with correct and incorrect "same" and "different" decisions.

377. Nickerson, R. S. Response time to the second of two signals following varied vs constant intersignal intervals. Perception & Psychophysics, 1968, 4, 78-80.

The Ss made choice responses under three experimental conditions: (1) a variable interval between the warning signal and the signal to respond, (2) a constant interval between the warning signal and the signal to respond, and (3) omission of the warning signal. With variable intersignal intervals (ISI), response time (RT) was inversely related to ISI at least when the latter was in the 10 to 225 msec range. When ISI was constant its duration had no perceptible effect on RT. RT tended to be shorter with constant ISI, independent of its duration, than when the warning signal was omitted altogether.

378. Nickerson, R. S. Note on "Same-Different" response times. Perceptual and Motor Skills, 1968, 27, 565-566.

Ss judged whether the second of two visually presented letters was the same as the first. In previous experiments of this type the occurrence of the first letter effectively partitioned the letters that could occur second into two sets of unequal size: the single letter to which the correct response would be "same" and several letters to which the correct response would be "different." In the present experiment, the stimulus set contained only two letters; thus given the occurrence of the first stimulus, one (second) letter would require the response "same" and one would require the response "different." As in the earlier studies, RTs associated with the decision "same" tended to be shorter than those associated with the decision "different."

379. Nickerson, R. S., & Burnham, D. W. Response times with nonaging foreperiods. Journal of Experimental Psychology, 1969, 79, 452-457.

Foreperiods (FRs) were generated in such a way that the probability of the immediate termination of an FP was independent of its age. Under these conditions mean response time (RT) increased linearly with mean, or expected, FP when the latter was varied from 250 msec. to 32 sec.

380. Nickerson, R. S., Collins, A. M., & Markowitz, J. Effects of uncertain warning signals on reaction time. Perception & Psychophysics, 1969, 5, 107-112.

Three experiments were conducted in an attempt to assess the effectiveness of a warning signal in reducing reaction time when (1) the signal to respond (danger signal) follows the warning signal with a probability less than 1.0, and (2) the interval between warning and danger signals (W-D interval) is variable. The required response was the depression of a foot pedal, as in automobile braking. It was determined that probabilistic warning information could be effective if observers made use of the W-D interval to prepare to make the response required by the danger signal. It was noted, however, that observers differed considerably in their tendency to do this. A model was proposed for describing different response strategies.

381. Nickerson, R. S., & Feehrer, C. E. Stimulus categorization and response time. Perceptual and Motor Skills., 1964, 18, 785-793.

Generally, in disjunctive reaction time experiments there is a one-to-one correspondence between the number of stimulus alternatives and the number of response alternatives. Consequently, the roles of stimulus recognition or categorization processes and response choice processes are confounded in the data. Two experiments were conducted in which the stimulus set was mapped onto the response set in a many-to-one-fashion. In each case S's task was to press a key in response to those stimuli designated as "critical" and to not press the key in response to stimuli designated as "non-critical." In the first experiment RT increased monotonically as the number of different stimuli in the critical stimulus category was increased from one to four. In the second experiment RT varied with the number of independent disjunctively combined attributes used to designate the critical category.

382. Nishisato, S., & Wise, J. S. Relative probability, interstimulus interval, and speed of the same-different judgment. Psychonomic Science, 1967, 7, 59-60.

Pairs of tones were judged to be "same" or "different" by four well-practiced Ss. The speed of these judgments, measured as reaction time (RT), was studied as a function of the relative probability of "same" trials and the interstimulus interval. Three levels of probability (.75, .50, and .25) and three interstimulus intervals (1 sec., 0.5 sec., and simultaneous presentation) were used. A four-way analysis of variance showed the judgment "same" to have longer RT than the judgment "different," and the middle interval (0.5 sec.) to have a shorter reaction time than either of the other intervals. Probability did not show any significant main effect; possible reasons for this are discussed.

383. North, J. A., Grant, D. A., & Fleming, R. A. Choice reaction time to single digits, spelled numbers and "right" and "wrong" arithmetic problems and short sentences. Quarterly Journal of Experimental Psychology, 1967, 19, 73-77.

Average RT to single number stimuli were found to differ significantly, with the shorter RTs being evoked by 1, 2, 6, and 9. The relationship was most marked when the numbers were presented visually as digits but held also when the numbers were printed as words.

RT for classification of simple three-digit addition and subtraction problems as correctly or incorrectly added or subtracted was shortest for correct additions and about equal for incorrect additions and correct and incorrect subtractions, implying a difference in processing of these forms of information. Similarly, dubitably false sentences were more slowly classified as "true" or "false" than were indubitably false sentences and either dubitably or indubitably true sentences.

384. Nystrom, C. O., & Grant, D. A. Performance on a key pressing task as a function of the angular correspondence between stimulus and response elements. Perceptual and Motor Skills, 1955, 5, 113-125.

5 groups of 18 Ss per group performed a key-pressing task which differed between groups in that the stimulus light display took angular orientation relative to a fixed horizontal set of keys of 0°, 45°, 90°, 135°, and 180° counterclockwise. Orthogonally to this independent variable, half the Ss matched 2-light patterns, the other half matched 4-light patterns. After 9 blocks of 25 2- or 4-light matches, each S was shifted to 4- or 2-light patterns, respectively. It was found that: (a) There was a significant difference in the effects on performance due to the stimulus light orientation variable. While it was observed that, the greater the angular displacement, the less compatible (as indicated by average time per match) were the S-R elements, only the 135° and 180° stimulus light orientations were statistically different from other orientations. (b) 2-light patterns were matched significantly faster than 4-light patterns, with an overall advantage of 1.10 sec. per pattern on the average. (c) The number-of lights-per-pattern interacted with the stimulus light orientation effect on performance during the first 9 blocks of patterns, in that a somewhat different relationship existed between pattern-matching time and simulus light orientation depending on whether 2-light or 4-light patterns were employed. (d) Performance was found to be much less impaired by employing changes in angular stimulus light orientation than when the spatial correspondence between S-R elements was altered as in the study by Morin and Grant (4) performed on the same experimental

apparatus. (e) Greater positive transfer effects were apparent in transferring from 4-light to 2-light paterns than in transfeering from 2-light to 4-light patterns. (f) Although initially the degrading effect of angular orientation was greater for the 4-light patterns than for the 2-light patterns, after training the angular effect was equal.

O

385. Ogasawara, I. Relation between S-R compatibility and reaction time in information processing. Japanese Psychological Research, 1967, 9, 28-34.

Previous studies showed that the relation between the reaction time and the amount of information of the stimulus was an increasing linear function. There are some reports, however, in which the slope of the function was found to be zero. To account for this phenomenon the notion of "compatibility" was introduced and utilized by Fitts, Davis and others.

The present study investigated the notion of compatibility for different sensory modalities in stimuli and responses, for different kinds of stimuli and responses. Results indicted that the kind of responses was the more important factor to determine the reaction time than S-R compatibility itself. Expecially, the reaction time of the verbal responses revealed the different tendency from the other responses. Discussion was made on these factors.

386. Oldfield, R. C., & Wingfield, A. Response latencies in naming objects. Quarterly Journal of Experimental Psychology, 1965, 17, 273-281.

After some preliminary analysis of what is involved in naming objects, in which the possible role of classificatory systems in the memory store is discussed, it is shown experimentally that there are consistent differences between the times taken to respond to presented objects by uttering their names, variations between the performances of different individuals being outweighed by variations due to the different objects. Moreover, there is a high consistency between different individuals as to the ordering of objects in respect of their naming latencies. It is further shown that a high correlation exists between the time taken to name an object and the frequency with which its name occurs in the language as a whole, as estimated in the Thorndike-Lorge Word List. Some implications of these findings are discussed, especially with reference to possible mechanisms by which presented objects are visually identified, and the appropriate names retrieved from the "word-store."

387. Ollman, R. T. Fast guesses in choice reaction time. Psychonomic Science, 1966, 6, 155-156.

A model which describes the effect fast guesses must have on observable choice latencies and probabilities is developed, strengthened, and tested with encouraging results. With the model, it is possible to estimate "true" decision times and probabilities without requiring error-free performance in discriminative reaction time.

388. Ollman, R. T. Central refractoriness in simple reaction time: The deferred processing model. Journal of Mathematical Psychology, 1968, 5, 49-60.

The well-known single channel conception of the human operator gives rise very naturally to the deferred processing model for simple reaction time. The predictions of the model principally concern how features of the simple reaction time distribution depended on the foreperiod duration. When developed quantitatively and compared with published data, the predictions seem to be fairly seriously wrong.

P

389. Pachella, R. G., & Fisher, D. F. The effect of stimulus degradation and similarity on the trade-off between speed and accuracy in absolute judgments. Journal of Experimental Psychology, in press.

The experiment examined the effects of reduced discriminability upon absolute judgments in speeded and unspeeded tasks. Subjects were required to locate the position of a vertical bar marker which was shown in one of ten possible positions. Reaction time and information transmission measures were compared in conditions which varied: (1) the degradation of the background luminance of the stimulus and; (2) the narrowing of the stimulus field. Degrading the luminance influenced performance to the same extent regardless of the speed constraints, whereas the effects of narrowing of the stimulus field were reduced as the speed constraints increased.

390. Pachella, R. G., Fisher, D. F., & Karsh, R. Absolute judgments in speeded tasks: Quantification of the trade-off between speed and accuracy. Psychonomic Science, 1968, 12, 225-226.

The Ss engaged in making absolute judgments were gradually forced to increase the speed of their responses. Information transmission decreased linearly as criterion time was decreased from 1.0 sec to 0.4 sec.

391. Pachella, R. G., & Pew, R. W. Speed-accuracy tradeoff in reaction time: Effect of discrete criterion times. Journal of Experimental Psychology, 1968, 76, 19-24.

In a choice reaction time (CRT) experiment that simultaneously varied the relative payoffs for fast and accurate responding and the criterion time defining fast vs. slow responses, it was shown that both the relative payoffs and the choice of criterion time have effects on CRT and errors. Of the 2, the criterion-time effect appears to be more stable with practice. A modification of the statistical decision theory model of CRT is suggested to fit these data and a methodological problem concerning the use of such discrete-criterion payoff schemes is discussed.

392. Pease, V. P. The intensity-time relation of a stimulus in simple visual reaction time. Psychological Record, 1964, 14, 157-164.

Visual reaction time data were taken to flashes varying in duration and luminance to investigate the I·t=C relationship over a wide stimulus range. 3 Ss were used and the data indicated that RT decreases with increases in duration up to a critical duration after which luminance alone determines the response, and that critical duration depends upon flash luminance.

393. Pease, V. P.,& Sticht, T. G. Reaction time as a function of onset and offset stimulation of the fovea and periphery. Perceptual and Motor Skills, 1965, 20, 549-554.

Reaction times were obtained for the onset and offset of luminous stimuli of 31,400 mL., .314 mL., 3.14 mL., and 1.98 mL., presented in the fovea and periphery. It was found that in the periphery offset RTs are longer than onset RTs. The opposite is true for the fovea. In both the fovea and periphery the differences between the onset and offset RTs decrease as the luminance increases.

394. Perriment, A. D. The effect of signal characteristics on reaction time using bisensory stimulation. Ergonomics, 1969, 12, 71-78.

Sixty-four subjects were tested to examine the effect upon reaction time of the composition of bisensory signals simultaneously presented in two sensory modes. The stimulus display consisted of a flash of light from one of two lamps and a 1000 cps tone presented at one or other earphone of a binaurally balanced headset. Subjects responded by depressing push buttons. The three response code variables examined were the code carried by each of the operating limbs; the code carried by the operating digits of each hand; and the degree of separation between the button pairs. Signals were classified as either unilateral, both components of the audio-visual signal originating on the same side of the body mid-line, or bilateral, the separate components originating contralaterally. Clear and consistent differences in the reaction times given to unilateral and bilateral signals were found. An explanatory attempt in terms of differential cortical stimulation is considered, and rejected. An alternative explanation involving 'spatial expectancy' is offered, and found to have limitations.

395. Peterson, J. R. Response-response compatability effects in a two-hand pointing task. Human Factors, 1965, 7, 231-236.

An experiment was conducted to determine whether or not response-response compatability effects were present in a simple perceptual-motor task where simultaneous two-hand pointing responses were required. The results indicate that both response precision and movement time are affected by the particular combinations of responses used. The results are interpreted as supporting the contention that R-R compatibility effects do exist--even in quite simple perceptual-motor tasks. A distinction is made between Stimulus-Response (S-R) compatibility effects and Response-Response (R-R) compatability effects.

396. Peterson, J. R. Effects of S-R coding on the rate of gain of information. Department of Psychology, University of Michigan, Technical Report 05823-8-T, 1965.

The purpose of the experiments reported here was to examine the probable validity of three hypotheses: 1) The RT vs. H_t relationship is linear; 2) The intercept constant, a, is unaffected by variations in S-R coding rules; and 3) The slope constant, b, is highly dependent upon variations in S-R coding rules.

The results of the present experiment are: 1) The RT vs. H_t relationships were found to depart significantly from linearity for several of the S-R coding schemes studied; 2) The intercept constant, a, was found to be relatively insensitive to the S-R coding rules which were used; and 3) The slope constant, b, was found to be greatly affected by the S-R coding rules which were used.

In addition, the results indicate that the time it takes to process information in the RT task depends partly on the nature of individual S-R pairing in a particular total S-R ensemble and partly on the number of different types of S-R pairings used in the given total S-R ensemble.

397. Pew, R. W. Acquisition of hierarchical control over the temporal organization of a skill. Journal of Experimental Psychology, 1966, 71, 764-771.

A 2-state relay control system in which S controls the position of a continually moving target with 2 response keys is employed to test the validity of concepts of hierarchical organization in skill development. As training progresses with this task Ss tend to develop strategies for improving their performance which imply control of the effect of an ongoing sequence of responses rather than execution of each response as a separate unit. Interresponse-time analysis reveals 2 distinctive modes of performance, designated the open-loop mode and the modulation mode, both of which imply higher-level control of the timing of response sequences but that achieve this control in 2 different ways.

398. Pew, R. W. The speed-accuracy operating characteristic. Acta Psychologica, 1969, in press.

If one wishes to compare information processing efficiency across a set of tasks, at the very least it is appropriate to attempt to fix the error rate or to fix the response time and examine the error rate. A better procedure would be to regard the trade between speed and accuracy to be a parameter and compare the slopes and the intercepts of the resulting Speed-Accuracy Operating Characteristics.

It appears that in tasks which must be performed under time pressure, that is not meaningful to ask the question, "What is the cost in time of making an error?" because the cost depends on the level of accuracy at which one is operating at the moment. An error saves more time at high levels of accuracy than at low levels. Rather one should ask, "How long does it take to increase the confidence of one's judgment by a factor of 10 or 100?"

399. Pickett, R. M. Response latency in a patern perception situation. Acta Psychologica, 1967, 27, 160-169.

The hypothesis that response latency is directly related to size of sample in a statistical discrimination process was tested in a visual pattern perception situation. Subjects were required to categorize each of a sequence of patches as Coarse or Even in texture relative to a designated criterion. Speed and accuracy of performance were determined for patches at various degrees of variation in texture on either side of the criterion. Effects of texture variations on combined response latency and response probability were consistent with a sequential sampling model of the discrimination process. Effects on conditional response latency were not.

400. Pierson, W. R., & Rasch, P. J. Determination of a respresentative score for simple reaction time and movement time. Perceptual and Motor Skills, 1959, 9, 107-110.

The reaction time and movement time of 260 male Ss between the ages of 8 and 30 were measured on 30 trials by a fractioning process employing two chronoscopes. For the population used, the following conclusions appear justified: (a) the mean of Trials 16 to 20 appears to be the most practical figure to use as a score representative of an S's speed of simple reaction and of movement as defined in this study, and (b) age is not a factor in the trial-to-trial improvement of reaction or movement time scores.

401. Pierson, W. R., & Rasch, P. J. Generality of a speed factor in simple reaction and movement time. Perceptual and Motor Skills, 1960, 11, 123-128.

The reaction time and movement time of 32 Ss were measured for arm extension, arm flexion, leg extension, leg flexion, and over-all body speed. For this population, the following conclusions appeared justified: (a) reaction time is conditioned by a general factor, (b) movement time is conditioned by a general factor, (c) arm flexion is a faster movement than the others tested, and (d) there is a low, but statistically significant, relationship between RT and MT.

402. Pierson, W. R., & Rasch, P. J. RT-MT correlations and the generality of a "speed factor." Perceptual and Motor Skills, 1961, 12, 246.

403. Pike, A. R. Latency and relative frequency of response in psychophysical discrimination. The British Journal of Mathematical and Statistical Psychology, 1968, 21, 161-182.

The relation between response latency and probability is discussed with particular reference to differences between mean times for correct and incorrect responses in difficult two-choice discriminations. The predictions of some finite Markov chain models for this situation are considered, and possible modifications of these simple systems which may bring about features of observed data are discussed. Some results, in the form of curves of the latency-probability relation, are presented from earlier work and new discrimination experiments. These data are discussed in relation to theoretical interpretations based on a particular stochastic model which describes psychophysical discrimination in terms of the accumulation of units contributing to the overt response.

404. Pitz, G. Use of response times to evaluate strategies of information seeking. Journal of Experimental Psychology, 1969, in press.

405. Pollack, I. Verbal reaction times to briefly presented words. Perceptual and Motor Skills, 1963, 17, 137-138.

Verbal reaction times were obtained for briefly presented words of vocabularies of different size. Reaction times increased with vocabulary size: initially, the increase was about 26 msec./bit; after four months of testing, the increase was about 13 msec./bit.

406. Pollack, J. D. Reaction time to different wavelenghts at varicus luminances. Perception & Psychophysics, 1968, 3, 17-24.

The present investigation is concerned with determining whether or not differences in the reaction times exist in a human subject's responses to 6 different wavelengths equated at 5 levels of luminance. The heterochromatic matching was done by the method of flicker photometry and checked by the method of direct comparison. Simple reaction time, the time interval starting with the presentation of a visual stimulus and terminating in a manual response, was used as the method of determining the latencies for the establishment of equal sensory effects for the different wavelenghts. Monocular viewing of the stimuli was used by two subjects and reaction times are determined over a luminance range of 5.2 log units around a central value of 1 millilambert. The results indicated that simple reaction time is inversely related to stimulus luminance. There were no differences in the reaction times to the different wavelengths at the four highest luminance levels; at the lowest luminance level, the wavelengths fan out in a manner that is in line with the classical data of vision. In other words, the visual functions obtained with simple reaction time parallel certain well-known visual functions in intesnsity discrimination, flicker and visual acuity-the results may be accounted for by the Duplicity Theory of vision.

407. Posner, M. I. Information reduction in the analysis of sequential tasks. Psychological Review, 1964, 71, 491-504.

This paper proposes a taxonomy of information-processing tasks. Information conserving, reducing, and creating operations are viewed as different methods of processing. The main concern of this paper is information reduction which, it is suggested, represents a kind of thinking in which the solution is in some way implicit in the problem, but in which the imput information must be reflected in a reduced or condensed output. A number of tasks withing the areas of concept identification and utilization are shown to have this character. If the tasks require complete representation of the stimulus in the response (condensation) the amount of information reduced is directly related to difficulty both during learning and in utilization of previously learned rules. If the tasks allow Ss to ignore information in the stimulus (gating) the direct relation between reduction and difficulty is found during learning but may not occur after the rule is learned.

408. Posner, M. I. Components of skilled performance. Science, 1966, 152, 1712-1718.

Human limitations of attention and memory are basic to the analysis of skilled performance.

409. Posner, M. I., Boies, S. J., Eichelman, W. H., & Taylor, R. L. Retention of visual and name codes of single letters. Journal of Experimental Psychology Monograph , 1969, 79, (Whole No. 1, Part 2).

If a stored letter can be matched more rapidly with a physically identical letter (e. g., AA) than it can with a letter having only the same name (e. g., Aa), then the stored representation must preserve something of the visual aspect of the letter. Immediately after the presentation of a letter, a physical match is about 90 msec. faster than a name match and this difference is lost after 2 sec. An interpolated information processing task abolished the difference between physical and name match RTs, but visual noise alone does not affect his difference. When the visual aspect of the letter is made a completely reliable cue, the efficiency of a physical match is maintained more adequately. If only the name of the first letter is presented, Ss show the ability to recode the information in a form which is as efficient as a physical match and more efficient than a name match. Consideration is given to the relevance of these findings to the general questions of decay, rehearsal, and generation of visual codes.

410. Posner, M. I., & Keele, S. W. Decay of visual information from a single letter. Science, 1967, 158, 137-139.

If the trace of a letter can be matched more rapidly with a physically identical letter (as in the pair AA) than it can be with a letter having only the same name (as in the pair Aa), then the trace must preserve the visual aspect of the letter. The visual information from a single letter decays in about 1.5 seconds if the task provides little incentive for preservation.

411. Posner, M. I., & Mitchell, R. F. Chronometric analysis of classification. Psychological Review, 1967, 74, 392-409.

This series of studies represents an effort to extend the subtractive method of Donders to the analysis of depth of processing in simple classification tasks. The stimuli are always pairs of items (letters, nonsense forms, digits) to which S must respond "same" or "different" as quickly as possible. Levels of instruction are physical identity (e. g., AA), name identity (e. g., Aa), and rule identity (e. g., both vowels). By use of the subtractive method, times for matches at each level are analyzed. The emphasis is not placed upon the itmes themselves but upon their relevance for understanding the operations and mechanisms involved in perceptual matching, naming, and classifying.

412. Posner, M. I., & Taylor, R. L. Subtractive method applied to separation of visual and name components of multiletter arrays. Acta Psychologica, 1969, in press.

If a stored letter can be matched more rapidly with a physically identical letter (e. g., AA) than with one having only the same name (e. g., Aa) the physical match reflects a visual memory code. In the first study the number of letters in store was varied from one to four. The efficiency of the visual code for a given letter is not reduced by the presence of other letters in the array. However, for longer array lengths only some of the letters give evidence of a physical match which is more efficient than a name match. The second set of experiments attempted to manipulate the efficiency of stored visual and name codes. This was done by varying the visual and acoustic similarity of the array. It was found that visually similar arrays reduced the efficiency of the physical match without affecting the name match. This finding indicated that the visual and name codes were separately stored and that these codes were not interrogated serially.

413. Poulton, E. C. Perceptual anticipation and reaction time. Quarterly Journal of Experimental Psychology, 1950, 2, 99-112.

To determine the effect of perceptual anticipation upon reaction time, two different types of experiment were carried out. In the first a skilled response had occasionally to be altered at a given point after a variable warning period. In the second the subject had to react to two auditory signals separated by a short time interval which was systematically varied, the second signal being expected or unexpected.

It was found that lack of readiness to respond to a signal, as revealed by a lengthened reaction time, may be due either to the subject not having prepared himself, as he was not expecting the signal; or to the subject not being able to prepare himself in time. Preparation for reacting to the second of the two signals, when both are expected and have to be reacted to, never appears to take more than between 0·2 and 0·4 seconds, as judged by reaction time. On the majority of occasions it appears to be complete in 0·2 seconds. These times are shorter than those usually given, because the extra delay due to incorrect anticipation has been excluded. With intervals of 0·1 seconds or less, delay in the second reaction may be due to the mechanical difficulty of responding quickly enough, expecially when the two reactions have to be made in opposite directions.

The finding that lack of readiness might be due to the subject not expecting the signal, and the further finding that preparation took longer when a skilled response had to be extended than when it had to be stopped, both suggest that so-called psychological refractoriness is due to lack of foreperiod in which to prepare for the response, rather than to a "psychological refractory phase" comparable to the refractory phase of nerves. If, by dividing his attention, the subject was able to prepare for his next response while making his previous one, so-called psychological refractoriness could be completely absent.

414. Poulton, E. C. The precision of choice reactions. Journal of Experimental Psychology, 1956, 51, 98-102.

It was desired to determine whether a one-choice reaction is made with greater precision than a two-choice reaction. A subsidiary aim was to determine whether a two-choice reaction is affected by the insertion of 50% of catch tests.

An auditory signal was presented either to the right or to the left of S, and he had to react in the corresponding direction with a 1-in. movement to the right or a 2-in. movement to the left. A criterion that combined time and precision had to be met. In the one-choice condition he knew in advance the direction an time of presentation of each signals was arranged in a simple pattern that was learned before the condition was performed. In the two-choice condition he was told in advance that there were only two possible times of presentation, and only two possible directions of the signal, but that the order was random.

It was found that the one-choice condition was performed with greater precision than the two-choice condition. There was no difference in the two-choice condition between the two possible times of presentation of the signal. Thus 50% of catch tests had no effect in this condition. When the two-choice condition was performed after the one-choice condition, RT's were about .05 sec. shorter than those usually reported. There was evidence of an interaction between the 1-in. and 2-in. movements.

415. Purohit, A. P. Effect of unexpected increase in stimulus intensity on reaction time of hand withdrawal. Psychonomic Science, 1966, 6, 387-388.

Latencies of hand withdrawal to a weak stimulus (RTw) and to a strong stimulus, the intensity of which was increased unexpectedly (RTs) were obtained from 32 male and 32 female Ss. Most Ss showed facilitatory effect in their RTs. This and other results have been discussed with reference to the findings of an earlier study in which Ss were required to press a reaction time key in the same situation. A modification of curvilinear theory of performance has been suggested.

R

416. Raab, D. H. Effect of stimulus-duration on auditory reaction-time. American Journal of Psychology, 1962, 75, 298-301.

The simple reaction-time (RT) to a noise burst was measured as a function of burst-duration. Two intensities of noise were employed, and duration was varied between 2 and 100 m. sec. The RT decreased with increasing duration, reaching a minimum in approximately half the duration required for the full growth of loudness. Stimulus-energy delivered at the start of this critical duration is less effective than energy delivered toward the end. The results of this and related studies are taken to mean that there is no one 'Reciprocity Law' for a sensory system. The trading function which relates intensity and duration depends on the performance being tested.

417. Raab, D. H. Statistical facilitation of simple reaction times. Transactions of the New York Academy of Sciences, 1962, 24, 574-590.

A model for reaction time, (RT) based on the statistical treatment of the multiple O problem in psychophysics by Smith and Wilson is presented. The model "unit" is a receptor-neural channel with Gaussianly varying signal latency. Distributions remain bell-shaped when sampling across channels. The model defines n channels with different latency distributions. RT is defined by the distribution of those neural signals that first arrive at some center. An alternate model, giving some weight to later signals may be more adequate.

418. Raab, D. H., & Fehrer, E. The effect of stimulus duration and luminance on visual reaction time. Journal of Experimental Psychology, 1962, 64, 326-327.

419. Raab, D. H., Fehrer, E., & Hershenson, M. Visual reaction time and the Broca-Sulzer phenomenon. Journal of Experimental Psychology, 1961, 61, 193-199.

Previous studies of the effect of stimulus duration on Rt have shown that RT increases as stimulus duration increases beyond approximately 50 msec. In Exp. I, in which six durations ranging from 10 to 500 msec. were presented in random order, RT did not vary with stimulus duration. RT was, however, found to be a decreasing function of luminance and of foreperiod duration. In Exp. II, in which 50- and 250-msec. flashes were presented in blocks of 18 trials each, a small but significant difference in favor of the briefer flash was found.

Our results suggest that attempts to explain the earlier findings on the basis of the Broca-Sulzer phenomenon are not justified. Instead, attitudinal factors that could develop when a given stimulus duration is presented repeatedly, as in the previous studies, are more likely to be reponsible for the RT differences that have been reported.

An unsuccessful attempt to verify the Broca-Sulzer effect by the method of single stimuli indicates that this effect may require asynchronous stimulation of a neighboring retinal area. It was not observed in the absence of a comparison stimulus Instead, phenomenal brightness increased with flash duration.

Under the range of conditions investigated, it is stimulus rather than apparent intensity that determines RT. The phenomenal brightness differences which were correlated with stimulus duration had no effect on reaction latency.

420. Raab, D. H., & Grossberg, M. Reaction time to changes in the intensity of white noise. Journal of Experimental Psychology, 1965, 69, 609-612.

Reaction time to a noise burst (ΔI) added to ongoing noise (I) was found to decrease with increasing ΔI and with decreasing I. For constant values of $\Delta I/I$, RT generally decreased with increasing I-a finding of significance for decision models of RT.

421. Rabbitt, P. M. A. Effects of independent variations in stimulus and response probability. Nature, 1959, 183, 1212.

422. Rabbitt, P. M. A. Errors and error correction in choice-response tasks. Journal of Experimental Psychology, 1966, 71, 264-272.

The latencies of responses preceding errors, of errors, of responses made the correct errors, and of responses following error correction were examined in a 4-choice and in 2 10-choice continuous-performance choice-response tasks (groups of 17 and 18 young Ss). Latencies of responses preceding errors were not different from the mean latency for all correct responses. Errors and responses correcting errors were 100-150 msec. faster than equivalent correct responses (p .01). The first correct response following error correction was slower than other, equivalent, correct responses. No aftereffects of committing an error upon response rate were observed beyond the 2 responses following error correction. An attempt was made to classify errors into different, causally related types, and some practical and theoretical implications of the results are described.

423. Rabbitt, P. M. A. Times for transitions between hand and foot responses in a self-paced task. Quarterly Journal of Experimental Psychology, 1966, 18, 334-339.

In a self-paced task subjects responded to each of four equally probable signals with a different one of their four limbs. Response times were examined as a function of the 16 possible transitions between limbs. Repeated responses were shown to be faster than any other transitions, while responses following responses with an ipsilateral limb were relatively slow. The implications of these results for models for the "repetition effect" are discussed.

424. Rabbitt, P. M. A. Time to detect errors as a function of factors affecting choice-response time. Acta Psychologica, 1967, 27, 131-142.

The time taken to detect errors committed in serial, self-paced choice-response tasks was measured at two levels of practice and under six experimental conditions known to affect choice-response time. Early in practice conditions affecting correct RT also affected error detection RT. After practice error detection RT was constant between tasks in which mean correct RT varied significantly. The data permit some choice amongst a series of models for the process of error detection.

425. Rabbitt, P. M. A. Signal discriminability, S-R compatibility and choice reaction time. Psychonomic Science, 1967, 7, 419-420.

With a very simple display, signal discriminability and S-R compatibility interact in their effects on choice RT. This result is discussed in the context of previous demonstrations of interactions between a number of different variables affecting choice RT.

426. Rabbitt, P. M. A. Three kinds of error-signaling responses in a serial choice task. Quarterly Journal of Experimental Psychology, 1968, 20, 179-188.

During serial self-paced choice response tasks mean reaction times (RTs) for responses which are made in order to correct errors are faster than mean RTs for other correct responses. Experiment I showed that subjects can accurately correct errors in a four-choice task by making the response which they should have made, even thought they are given no indication that and error has occurred. Experiment 2 showed that subjects correct their errors faster and more accurately when they use correction procedure than when they make a common response to all errors. The implication that subjects can correct errors because they know what response they should have made allows some comments on the constraints which must be met by various models which have been proposed to explain error-correction.

427. Rabbitt, P. M. A., & Phillips, S. Error-detection and correction latencies as a function of S-R compatibility. Quarterly Journal of Experimental Psychology, 1967, 19, 37-42.

In choice-response tasks employing correction-procedure, error-correcting responses are typically found to be faster than equivalent correct responses. An experiment was made to compare error-correction RT under conditions of good and poor S-R compatibility in a two-choice task. After practice, variation in S-R compatibility producing significant variations in mean correct RT nevertheless have no effect on error-correction time. The contrast between this result, and one previously reported (Burns, 1965) leads to a re-discussion of the processes of error detection and correction.

428. Rabbitt, P. M. A., & Rogers, M. Age and choice between responses in a self-paced repetitive task. Ergonomics, 1965, 8, 435-444.

When young subjects select between two responses of similar amplitudes, and in the same direction, they can overlap identification of one of two signals with the initial movement of a reach appropriate to either. They thus respond more quickly when selecting between responses of similar amplitudes than when selecting between responses of very different amplitudes. Older subjects are less able to overlap movement and choice time and so benefit less from a choice between similar as against dissimilar responses. Young subjects respond faster when cycles of responses during the task are alternated than when they are repeated. This tendency appears to be related to guessing strategies earlier described as the 'negative recency effect' or 'gambler's fallacy'. The latencies of young subjects' responses appear to be directly dependent on the latencies of immediately preceding responses rather than on the response rate for the sequence as a whole. Latencies of old subjects' responses are affected by both factors. Implications for the design of consoles are discussed.

429. Rains, J. D. Reaction time to onset and cessation of a visual stimulus. Psychological Record, 1961, 11, 265-268.

An experiment was conducted to determine if differences exist in reaction time to onset and cessation of a large, bright, foveal light. Out of 21 replications of the experiment, eight differences, split equally between the two types of reactions, were significant. These findings are attributed to the trained subjects' sensitivity to momentary fluctuations in their physiological and psychological states. It is concluded that no differences between the two types of reaction are apparent at these parameters.

430. Rains, J. D. Signal luminance and position effects in human reaction time. Vision Research, 1963, 3, 239-251.

Reaction time of 3 trained subjects is measured under four conditions of flash luminance at nine retinal positions along the horizontal meridian. The interaction between retinal position, intensity and reaction time is discussed. When reaction time is plotted as a function of retinal position, different functions are derived for stimuli at photopic levels than for stimuli in the scotopic range. The relationship between density of retinal elements at a given locus of stimulation and reaction time at that locus is examined. An hypothesis is advanced to account for this relationship.

431. Rapoport, A. A study of disjunctive reaction times. Behavioral Science, 1959, 4, 299-315.

To decide what to do means to choose an appropriate response to a situation. In the simplest case, the situation may be one of several stimuli, to each of which there is a "correct response." Other studies have indicated that the latency of the response is positively correlated with the number of stimuli from which the stimulus presented is selected, or more specifically, that the latency is approximately a linear function of the uncertainty (measured in information units) of the stimulus. The present study turns attention to possible neural models to explain such results and to account for the observed statistical distributions of reaction time associated with the recognition of the stimulus and with the decision to act.

432. Reiter, H. H. Effects of noise on discrimination reaction time. Perceptual and Motor Skills, 1963, 17, 418.

433. Reynolds, D. Effects of double stimulation: Temporary inhibition of response. Psychological Bulletin, 1964, 62, 333-347.

This paper deals primarily with findings in the area of reaction time, with a lesser focus on dichotic listening studies and stereoscopic perception. The generality of a temporary inhibition of response (TIR) phenomenon, given double stimulation in close temporal contiguity, is posited. 3 alternatives are offered: an S-centered (information and/or "filter" theory), an O-centered (the "expectancy" position), and an R-centered (a competing-response position) explanation. The latter is suggested as most adequately dealing with the data, although the alternatives are not seen as mutually exclusive. A method for the training of prepotent responses is suggested, along with an associated line of research into the TIR phenomenon.

434. Reynolds, D. Time and event uncertainty in unisensory reaction time. Journal of Experimental Psychology, 1966, 71, 286-293.

Prior bisensory studies in reaction time (RT) have not obtained a pure speed measure of response latency. Errors in tracking tasks and differential latencies to bisensory stimuli are confounded with pure response latency; such results cannot adequately explain the psychological refractory period (PRP). Using pairs of visual stimuli, event uncertainty was held at 0 while temporal uncertainty was manipulated. Results show: (a) a general rise in mean 1st RT as a function of ISI length; (b) the PRP seems inversely related to "practice" of Ss; (c) some evidence for extinction of competing responses accounting for the shapes of the RT curves. A competing response theory was offered to explain PRP, thought a special case of the "Temporary Inhibition of Response" phenomenon (Reynolds, 1964a).

435. Riegel, K. F., & Birren, J. E. Age differences in choice reaction times to verbal stimuli. Gerontologia, 1967, 13, 1-13.

A total of 30 young and 23 elderly men and women, before 10 light stimuli, pushed buttons to turn off particular lights as indicated by verbal cues. Large differences were obtained between age groups, between 1st and 2nd trials, and between tasks. Differences in long-term verbal habits seem to explain age differences in the various reaction tasks.

436. Robinson, G. H., & Leifer, R. P. Generality of Fitts' law under differential error instruction. Perception and Motor Skills, 1967, 25, 901-904.

This experiment examines the applicability of Fitts' "channel capacity" model for discrete motor movements in a situation where the error rate (missing the target) is substantially increased and the resulting movement time decreased. Two experimental groups averaged approximately 3% and 19% error but yielded essentially the same information transmission rate in bits per second. The generality of the law over a wide error range is therefore indicated.

437. Rubinstein, L. Intersensory and intrasensory effects in simple reaction time. Perceptual and Motor Skills, 1964, 18, 159-172.

Reaction time was measured as a function of the interval between an irrelevant stimulus, and a reaction stimulus, for visual and auditory stimuli. Reaction time was inversely related to the length of the interval, when both stimuli were in the same sense mode, but remained relatively constant for stimuli differing in sense mode. Both the absolute and the percentage change in RT were greatest when both stimuli were visual; in the latter case, the changes in reaction time resulting from the variation of interval length were independent of the luminances of both the irrelevant and the reaction stimuli.

438. Rubinstein, L. Disjunctive reaction times within and between sense modes. Perceptual and Motor Skills, 1964, 18, 405-408.

Choice reaction time to a light in the right eye was measured as a function of the other stimulus in the choice pair, either a sound, a light in the left eye, or a weaker light in the right eye at the same retinal locus. This reaction time shortened with practice and was independent of the nature of the other stimulus. The superiority of inter- vs intrasensory coding is questioned.

439. Rubinstein, L., & Rutschmann, J. Reduction of the "psychological refractory period." Perception & Psychophysics, 1967, 2, 499-502.

The usual increase in reaction time which occurs when a reaction stimulus is preceded by one irrelevant stimulus was reduced 30% by preceding the latter with a second irrelevant stimulus at certain critical intervals between stimuli. The interaction between the irrelevant stimuli, as measured by reaction time, has a different time course than the interaction implicit in the "psychological refractory period".

440. Rutschmann, J., & Link, R. Perception of temporal order of stimuli differing in sense mode and simple reaction time. Perceptual and Motor Skills, 1964, 18, 345-352.

Judgments of temporal order (method of constant stimuli) were obtained as a function of the delay between the onset of a visual and an auditory stimulus. Simple reaction times were also obtained to both the visual and the auditory stimulus. Differences in reaction time could not be used to predict the stimulus asynchrony for temporal order judgments, because the onset of the auditory stimulus had to precede the onset of the visual stimulus for 50% judgment of "click first," whereas the auditory reaction time was significantly shorter than the visual reaction time. A speculative explanation is offered to account for the differences between the present findings and those of Hirsh and Sherrick (1961).

S

441. Saltzman, I. J., & Garner, W. R. Reaction time as a measure of span of attention. Journal of Psychology, 1948, 25, 227-241.

Two techniques for measuring the span of attention were compared. With one technique tachistoscopic presentations were used with an exposure time of 0.5 second. With the other technique the reaction-time required for the correct identification of the various numbers of stimulus objects was measured. The stimulus objects used were primarily concentric circles, although comparison measures were also obtained with dots. The results show that the type of function obtained with the tachistoscopic presentation of the circles is the same as that found with other stimulus objects. Small numbers of rings are always identified only some of the time. Reaction time measured show a continuous increase in reaction time as the number of rings increases. There is no minimum number of objects below which the reaction time remains constant. Both techniques reveal a training effect, but the percentage of correct reports is greatly increased with the tashistoscopic procedure, as soon as the total range of the stimulus objects is made known to the observers.

442. Sanders, A. F. The selective process in the functional visual field. Soesterberg - The Netherlands: Institute for Perception RVO-TNO, 1963.

443. Sanders, A. F. Selective strategies in the assimilation of successively presented signals. Quarterly Journal of Experimental Psychology, 1964, 16, 368-372.

It is found that performance in experiments on the psychological refractory period is highly affected by instructions. In the present experiment subjects were instructed either to handle the signals successively or to group them. Both instructions were obeyed. This seems to indicate that the human organism has various strategies available. Which strategy is actually applied is likely to depend on the structure of the experimental situation, and partly also, on momentary preference. This may explain the variety of results in the literature on this subject.

Finally, it is found that, when two signals are presented simultaneously, the total reaction time is considerably shorter if the signals are "grouped" than if they are "handled successively." This difference disappears at interstimulus intervals of 0-2 sec. and 0-4 sec. The hypothesis is put forward, that the gain in time at the former case is due to simultaneous perceptual processing of the signals.

444. Sanders, A. F. Prewarning signal activity and RT as a function of foreperiod. Perceptual and Motor Skills, 1965, 21, 405-406.

Simple auditory RT was measured as a function of foreperiod and reading activity before the warning signal (W) arrived. Without prewarning signal activity earlier results were confirmed, showing a continuous decrease of RT with smaller foreperiods. When reading activity preceded W, no significant difference was found between foreperiods of 0.5 to 4.0 sec., suggesting preparation for response before arrival of W at short foreperiods.

445. Sanders, A. F. Expectancy: Application and Measurement. Acta Psychologica, 1966, 25, 293-313.

It is argued that the unsatisfactory status of the expectancy concept is mainly due to a lack of quantative data. In a variety of psychological topics expectancy phenomena have been demonstrated but not systematically measured. A concised review of the results is presented--the New Look movement, aspiration level, probabilistic concept formation and a number of reaction time issues. This is followed by a discussion of more recent work on the measurement of subjective probability on the basis of numerical estimation or rating. The studies on frequency estimation and Bayesian revision of opinion are especially considered in this respect. It is concluded that, in spite of a number of methodological problems, the time seems ripe to apply the estimation procedure as a more general measurement technique in situations where expectancy appears to be important.

446. Sanders, A. F. Some aspects of reaction processes. Acta Psychologica, 1967, 27, 115-130.

A number of issures about reaction processes are discussed in this paper. It seems likely that reactions are based upon a number of successive internal responses. One of the first may be labelled 'the elementary code', which is afterwards translated in response terms. If the response directly corresponds with the elementary code, the situation has an extremely high SR compatibility and CRT becomes independent from the number of alternative signals. Especially the translation stage of the reaction is thought to be dependent on information content; translation seems to be also the most critical stage in handling information, as far as errors and capacity are concerned.

Some experiments are reported showing that two successive responses to one signal--a compatible and an incompatible one--do not interfere with each other while two incompatible responses do. So, compatible response seems to be a station which is naturally passed when the SR combination is incompatible. Final topics concern the issues of information condensation, expectation and the statistical decision theory of reaction time.

447. Sanders, A. F., & Ter Linden, W. Decision making during paced arrival of probabilistic information. Acta Psychologica, 1967, 27, 170-177.

Four exploratory experiments are described in which the basic assumptions of the Edwards-Wald model for decision making in probabilistic sequential tasks are tested. The assumptions are (1) continuous revision of the likelihood ratio on the basis of incoming data and (2) a fixed decision criterion on the basis of costs and pay-offs.

The results suggested that the decision criterion shifts from rather strict to quite risky as clear evidence is postponed, so that the criterion is certainly not fixed. The findings were not contrary to the idea of revision of the likelihood ratio.

448. Schlesinger, I. M. Response uncertainty as a determinant of reaction time. Acta Psychologica, 1964, 22, 52-59.

The hypothesis that RT is a function of response uncertainty and not only information transmitted was put to test. For each of 16 Ss simple RT and disjunctive RT were measured under the following two conditions: (a) one response was to be made to each stimulus, as in the usual RT experiment, (b) for each stimulus two responses were appropriate, and S was instructed to employ either one; both responses had identical results and thus the choice could have been a matter of indifference to S.

It was found that the latter condition resulted in significantly higher RTs in the case of disjuctive RT, but only in an insignificant increase in the case of simple RT.

The implications of these findings--as well as of those suggesting that stimulus uncertainty may increase RT--were discussed, and a more complicated model of the organism in RT situations was outlined.

449. Schlesigner, I. M., & Melkman, R. The effect on choice-reaction time of stimulus information varied independently of transmitted information. Journal of General Psychology, 1966, 74, 165-172.

The authors hypothesized that performance in a reaction-time task is affected not only by the amount of information transmitted but also by the perceptual task resulting from characteristics of the stimulus display. The problem of varying stimulus information independently of transmitted information without increasing the "confusability" of the stimuli was solved in the following way: S was required to respond to either light in one set of two lights by depressing one pushbutton and to respond to either light in a second set of lights by depressing a second pushbutton. The relative frequencies with which the two lights (linked to one response) appeared varied for different experimental conditions. The following proportions were employed: 9-1. 7-3, and 5-5. Stimulus information was increased from one experimental condition to the next in the order given, whereas transmitted information was held constant for all conditions; i. e., there were always two equiprobable responses.

450. Schmidt, M. W., & Kristofferson, A. B. Discrimination of successiveness: A test of a model of attention. Science, 1963, 139, 112-113.

Interpreting attention as a periodic phenomenon, we show its relevance to discriminating the successiveness of signals presented ot separate sense modalities. Experiments confirm the expected linear relation between the probability of discriminating pairs of successive from pairs of simultaneous signals and make it possible to infer the period of attention.

451. Schneider, R. J., Stilson, D. W., & Ulehla, Z. J. Note on differential payoff and time-cost functions in choice reaction time. Perceptual and Motor Skills, 1968, 26, 309-310.

In a choice reaction-time (TR) situation with rewards for correct responses, the effect of the payoff scheme upon RTs appears to depend upon the way in which S is charged for the time he takes to respond.

452. Schouten, J. F., & Bekker, J. A. M. Reaction time and accuracy. Acta Psychologica, 1967, 27, 143-153.

The fraction of errors in a binary reaction experiment is found to depend upon reaction time. This effect, already apparent in a free reaction time experiment, is corroborated by using the method of forced reaction time. In this method the subject is instructed to react in coincidence with an additional command signal. The binary stimulus then serves as an information signal only.

The dependence of the fraction of errors upon reaction time seems to rule out any theory based upon the assumption that the subject reacts if and when he has obtained a fixed certainty regarding the quality of the stimulus.

453. Schvaneveldt, R. W. Effects of complexity in simultaneous reaction time tasks. Journal of Experimental Psychology, in press.

Two experiments investigated the effects of information load (number of alternatives) and S-R code in each of two simultaneously performed reaction time (RT) tasks. Subjects were required to make both a verbal and a manual response on each trial in the simultaneous performance conditions. Each task was also performed alone for comparison.

The results were: (a) In simultaneous performance, reaction time in each task is greater with more alternatives or an indirect S-R code in either task. (b) The complexity of the verbal task has a smaller effect on verbal RT when the complexity of the manual task is increased. (c) Details of the data argue against a response grouping interpretation. The evidence for overlap between the two tasks has important implications for the single-channel hypothesis.

454. Schvaneveldt, R. W., & Chase, W. G. Sequential effects in choice reaction time. Journal of Experimental Psychology, 1969, 80, 1-8.

Four experiments examined sequential dependencies in choice RT as a function of number of alternatives, S-R compatibility, and the intertrial interval (ITI). A fifth experiment investigated guessing strategies. The two-choice compatible RT data revealed speeded response to stimuli following certain alternating as well as some repeating sequences of stimuli. Similar patterns were obtained in the guessing task of Exp. V. Negative recency occurred in both the two- and four-choice compatible tasks, and negative recency increased as ITI decreased. With less compatible S-R codes, repetitions facilitated RT in both two- and four-choice tasks only after two repetitions. With a highly incompatible four-choice task, one repetition was sufficient to facilitate RT maximally. With incompatible codes, ITI had no effect. It was suggested that the sequential effects in choice RT reflect processing strategies which depend on the complexity of the S-R code.

455. Seibel, R. Discrimination reaction time as a function of the number of stimulus-response pairs and the self-pacing adjustment of the subject. Psychological Monograph, 1962, 76, (Whole No. 561).

The effects of amount of information on Discrimination Reaction Time (DRT) are examined. The experimental situation involved a display of patterns of five lights which the operator transcribed to a compatibly arranged five-key keyboard. Information was varied from one through approximately five bits. The DRT increases with information transmitted from one to approximately three bits, but shows no further increase from three to five bits. The motor difficulty of the response, i. e., the particular finger pattern, is the most important determiner of DRT. Interaction effects are found between specific pattern difficulty and difficulty of the set of patterns. The outline of a model to account for the results is presented. Central to the model is the variable referred to as the self-pacing adjustment of the S.

456. Seibel, R. Discrimination reaction time for a 1,023 alternative task. Journal of Experimental Psychology, 1963, 66, 215-226.

Stimuli were all possible patterns of 10 lights. Responses were corresponding patterns of simultaneous key depressions in a 10-key keyboard, (1 key for each finger). After more than 75,000 discrimination reaction time ((DRTs) for each of 3 Ss, average DRT under the 1023-alternative condition exceeds that under a 31-alternative condition by less than 25 msec. DRT does not increase linearly with information transmitted. Learning curves for the 1023-alternative task are described by: $Y' = (A)(X + E)^B + C$. Idiosyncratic and relatively long-term performance shifts limit the precision of fit. r^2 alone was not an adequate criterion of goodness of fit.

457. Sekuler, R. W. Signal detection, choice response times and visual backward masking. Canadian Journal of Psychology, 1965, 19, 118-132.

Visual backward masking was studied in a signal detection context. Receiver operating characteristic curves were generated by varying the probability that a test stripe would occur in the first flash of each two-flash sequence. In addition to "yes-no" data, choice response times were recorded unbeknownst to O. Times for correct responses were shorter than those for incorrect responses. The relevance of these data to models of choice time and psychophysics in general is discussed.

458. Seymour, P. H. K. Response latencies in judgments of spatial location. British Journal of Psychology, 1969, 60, 31-39.

Subjects were presented with the printed word above or below and a configuration consisting of a reference shape (a square) and a smaller shape of variable location (a blacked-in circle) which might appear ABOVE or BELOW the square. The instruction was to report 'yes' if the word and the location of the circle relative to the square were congruent, and 'no' if they were not. The latency of this judgement was measured from the simultaneous onset of the displays to the initiation of the verbal response. The pair above/ABOVE was classified as congruent significantly more rapidly than the pair below/BELOW or either of the mismatched pairs. The order in which word and configuration were fixated was a significant factor, response times being faster where the word was fixated first.

459. Shaffer, L. H. Choice reaction with variable S-R mapping. Journal of Experimental Psychology, 1965, 70, 284-288.

An experiment examined 2-choice reaction under fixed or variable mapping rules. Each display contained a signal, M, and a symbol representing a rule, I, that transformed it. In some conditions I and M came on the sequence. RT was always shorter under fixed than under variable I. When I was variable, presenting I or M in advance led to shorter RT, the reduction being greater for I. There were independent transition effects for I than for M: RT was shorter with repetition than with alternation under variable I and conversely under fixed I. RT was longer with contra- than with homolateral mapping under fixed I or if I was variable and given in advance, otherwise it was invariant with mapping.

460. Shaffer, L. H. Some effects of partial advance information on choice reaction with fixed or variable S-R mapping. Journal of Experimental Psychology, 1966, 72, 541-545.

2 experiments are reported on 2-choice reaction with variable S-R mapping. In the task a signal, I, designates a mapping relation between signal, M and response, R. Both I and M can be random variables in a trial sequence. In some conditions a value of I or of M or a neutral light was given in advance, with either ¼- or ½-sec. foreperiod. Response time was examined as a function of the advance alerting and of the transition from the previous trial. Both were significant variables and there was an interaction between them indicating distinct phases in the choice process. It was also shown that with a neutral advance signal there is an optimal foreperiod in the interval 0-½ sec. with fixed mapping but not with variable mapping.

461. Shaffer, L. H. Transition effects in three-choice reaction with variable S-R mapping. Journal of Experimental Psychology, 1967, 73, 101-108.

3 experiments examined response time in a 3-choice task using variable S-R mapping. Experiment I used self-paced trials and examined RT as a function of trial transition and of practice. Experiment II used self-paced trials and introduced a variety of conditions of advance information corresponding to an earlier 2-choice experiment. Experiment III replicated Experiment II but used discrete trials. Comparing the results of Experiments II and III showed that Ss were both slower and made less use of advance information with self-paced than with discrete trials. Comparing the results with those in the earlier 2-choice task revealed marked differences in the transition effects and it is not yet clear how these can be reconciled.

462. Shaffer, L. H. Refractoriness in information processing. Quarterly Journal of Experimental Psychology, 1968, 20, 38-50.

Two experiments on refractoriness were carried out in which the warning, first and second signals, S_0, S_1 and S_2 respectively, were all single-valued, and the distributions of random intervals between S_0 and S_1 and S_2 were the same. In the first experiment the intervals in a trial were statistically independent: the null hypothesis, that the latencies of the two responses would be similar, was rejected, but the results were also found to agree with no existing alternative hypothesis. In the second experiment the intervals in a trial were conditionally related and the second response was found to be faster than in the first experiment. This is discussed in the context of the issue of serial or parallel processing of information.

463. Shaffer, L. H., & Hardwick, J. Typing performance as a function of text. Quarterly Journal of Experimental Psychology, 1968, 20, 360-369.

The performance of skilled typists was examined on texts ranging from prose to random letters, with the aim of discovering some of the factors that support its fluency. It was found that speed and errors were the same for prose and random word tests, and although performance got progressively worse on more degraded texts the biggest decline came between first- and zero-order random letter tests. The results were discussed in the context of several hypotheses about transcription processes, some assuming a statistical, left-to-right encoding of letters and others assuming linguistic encoding, either preserving the linguistic units in response units or translating the linguistic units into letter responses under the control of a sequencing process.

464. Shallice, T., & Vickers, D. Theories and experiments on discrimination times. Ergonomics, 1964, 7, 37-49.

Three models to account for discrimination times are examined: one being derived from information-theory, another being Crossman's Confusion Function and the third a form of Sequential Sampling model. Four experiments, using card-sorting tasks in which lines of different lengths had to be discriminated, were conducted and the results compared with those of previous experiments. It was concluded that:

1. Experiments in this field may be divided into two types. One type (A) involves a series of judgments the difficulty of which differs randomly from one to another. The other type (B) involves a series of judgments all of the same degree of difficulty.

2. Type B results in the present experiments were fitted moderately well by Crossman's Confusion Function, and somewhat less well by the Sequential Sampling model. They were not well fitted by the information-theory model.

3. Type A results had previously been shown to be well fitted by an information-theory model when each individual discrimination was separated in time from others. It was found that when discriminations were made as a continuous series, the relationship between difficulty and discrimination time broke down.

465. Sidowski, J. B., Morgan, R., & Eckstrand, G. Influence of task complexity and instructions upon simple and discrimination reaction times. Journal of Experimental Psychology, 1958, 55, 163-166.

The present experiment investigated the influence of task complexity and instructions upon simple and discrimination RT. The standard procedure for measuring RT was used; however, after releasing the key S made one of three possible responses which differed in complexity. The three responses ranges from a simple finger withdrawal to a one-switch manipulation response, to a more complex three-switch response. Group I (N=24), with RT instructions, was told that this was a RT experiment and that E was primarily interested in measuring the fastest RT possible. Group II (N=24), with total movement time instructions, was told to direct attention to obtaining as fast a total movement time as possible (total movement time included both RT and switch manipulation times). Each S in both groups served under simple reaction and discrimination RT conditions.

Analysis of the data showed no significant differences in RT between instructions. Discrimination conditions were found to produce longer RT's than did simple reaction conditions. Task complexity was also found to have a significant influence upon RT. The influence of task complexity was found to be a function of reaction type, discrimination or simple.

466. Siegenthaler, B. M., & Hochberg, I. Reaction time of the tongue to auditory and tactile stimulation. Perceptual and Motor Skills, 1965, 21, 387-393.

Measures of reaction time of the tongue to tactile stimulation on the lips and to a 1000-cps tone at sensation levels of 10, 50, and 70 db were obtained from 26 normal young adults. Results revealed that tactile stimulation evoked the shortest reaction time (M=.123 sec.); 70 db elicited slightly longer reaction time (M=.129 sec.); 50 db still longer reaction time (M=.137 sec.); and 10 db the longest (M=.209 sec.). The 10-db tone reaction time was significantly longer than that of any other stimulus condition, while tactile stimulus reaction time was significantly shorter than both the 10- and 50-db tonal stimuli, but not than the 70-db stimulus. Among the auditory conditions, 50 and 70 db were not significantly different from one another, but both were different from 10 db. The findings support the role played by tactual feedback in the oral region for monitoring speech. It is hypothesized that a speech mechanism which operates on a servosystem principle is likely to utilize the most efficient sensory channels available in monitoring speech output, with time of response being one important measure of efficiency.

467. Simon, J. R. Ear preference in a simple reaction-time task. Journal of Experimental Psychology, 1967, 75, 49-55.

This paper reports 3 experiments concerned with the effects of ear(s) stimulated, responding member, handedness, and age on simple auditory reaction time (RT). A 1,000-cps stimulus tone was presented to either the left ear, the right ear, or to both ears simultaneously. The Ss responded to the tone onset by depressing a finger key. Right- and left-hand blocks of trials were used. In Experiments I and II, Ss did not know prior to a trial which ear(s) would be stimulated. Under these conditions, they responded faster to right-ear stimulation than to left and, with the exception of an older group, were faster on binaural trials than on monaural trials. When Ss were informed in advance as to which ear would be stimulated (Experiment III), the differences previously noted were no longer apparent.

468. Simon, J. R. Signal processing time as a function of aging. Journal of Experimental Psychology, 1968, 78, 76-80.

Old and young Ss pressed a right- or left-hand key in response to the onset of 1 of a pair of lights. In Exp. I, a warning light indicated the approaching onset of the stimulus light but also communicated the rule governing the ensuing response; i. e., respond with key on the same or opposite side as the stimulus light. The interval (PI) between warning and stimulus lights was short (100 msec.) in one block of trials and long (1.5 sec.) in another. The difference in RT between the 2 blocks reflected the time S required to process the information in the warning light. Results indicated that signal reactions were unaffected by PI, but reversed reactions were slower on short than on long PI trials.

469. Simon, J. R., & Rudell, A. P. Auditory S-R compatibility: The effect of an irrelevant cue on information processing. Journal of Applied Psychology, 1967, 51, 300-304.

2 experiments demonstrated the existence of a strong population sterotype which affected the processing of verbal commands. In a choice RT task, Ss pressed the right- or left-hand key in response to the words "right" or "left" which were presented to the right or left ear. RT was significantly faster when the content of the command corresponded to the ear stimulated than when it did not; i. e., information processing was affected by a cue irrelevant to the task itself, the ear in which the command was heard. Removing S's uncertainty regarding the ear to be stimulated resulted in significantly faster RT, and reduced but did not eliminate the effect of the irrelevant directional cue.

470. Simon, J. R., & Wolf, J. D. Choice reaction time as a function of angular stimulus-response correspondence and age. Ergonomics, 1963, 6, 99-105.

This study was concerned with the effect of varying the angular orientation of a display on the choice reaction times of two age groups; a younger group ranging in age from 20 to 30 and an older group aged from 65 to 86. Two stimulus lights mounted on a vertical circular panel were rotated counterclockwise so that the lights formed angles of 0^o, 45^o, 90^o, 135^o, and 180^o with the horizontal. Changing the spatial relationship of the stimulus lights relative to the fixed position of two response keys increased the complexity of the task and provided a means for testing the hypothesis that age differences in reaction time increase with increasing task difficulty.

Results indicated significant differences in reaction time as a function of both display angle and age. With the least compatible display (180^o), reaction time was slowed 30%. The role of spatial cues in the process of translating display information into control action was discussed. The predicted interaction of task difficulty and age was not significant.

471. Slamecka, N. J. Choice reaction time as a function of meaningful similarity. American Journal of Psychology, 1963, 76, 274-280.

The hypothesis that choice reaction-time is directly related to the degree of meaningul similarity between words was tested in three experiments. The experiments differed only with respect to the continum of similarity along which the words ranged. Experiment I studied denotational (definition) similarity; Experiment II studied one connotational (properties or attributes) dimension; and Experiment III investigated word-differences lying along continua measured by the Osgood semantic differential technique.

The task was to choose that one of two words on a card which came closer in meaning to a designated third word. Choice reaction-times were obtained, and S then sorted the cards into three categories experssing his perception of the degree of similarity between the two choice-words on each card. For Experiment III, the similarity-levels were predetermined from normative tables.

The results showed consistently longer reaction-times for the choices between more similar alternatives. Moreover, the proportion of choices for each card, expressed in terms of uncertainty, revealed a positive relationship between mean reaction-time and degree of uncertainty. It is suggested that choice reaction-times could be used as criteria for the determination of degrees of similarity between stimuli lying along non-physical dimensions.

472. Slater-Hammel, A. T. Reaction time and speed of movement. Perceptual and Motor Skills Research Exchange, 1952, 4, 110-113.

Measurements of reaction time to light and speed of arm movement over an arc of 120 degrees were obtained from 25 male physical educations students. Mean reaction time was .224 seconds. Mean duration of movement was .238 seconds. Correlations of reaction time with several measures of movement ranged between -.07 and 17, not significantly different from zero. The results of this study are interpreted as simply indicating that measurement of reaction time cannot readily be used to predict speed of movement.

473. Smith, E. E. Effects of familiarity on stimulus recognition and categorization. Journal of Experimental Psychology, 1967, 74, 324-332.

In 2 different tasks Ss were instructed to press a "Yes" button if the stimulus word was a member of a predefined set of target words, and a "No" button otherwise; target sets were defined by enumeration in the E task, and by category membership in the C task. The size of the target set was either 1, 2, or 4 words or categories, and stimulus words varied in familiarity. Familiarity facilitated response times (RTs) in both tasks. The functions relating RT to size of target set in the E task were shown to reflect a memorial comparison process that follows recognition, and it was this memory process that was facilitated by familiarity.

474. Smith, E. E. Choice reaction time: An analysis of the major theoretical positions. Psychological Bulletin, 1968, 69, 77-110.

This report analyzes and evaluates (against experimental findings) contemporary theories of choice reaction time (CRT). The influence of Donders' subtraction method on current theory is assessed, followed by a view of experimental findings concerned with the effects on CRT of (a) number of alternatives, (b) stimulus probability, (c) stimulus value, (d) repetition of stimulus or response, (e) stimulus discriminability, (f) stimulus-response compatibility, (g) practice, and (h) emphasis on speed vs. accuracy. A 3-state conceptualization of the central mechanisms operative during the latent period—stimulus preprocessing, stimulus categorization, and response selection—is proposed. The theories are dichotomized on the basis of the process—template matching vs feature testing—which is assumed to underlie stimulus categorization. The analysis indicates that current theories have neglected response-selection processes and are consequently unable to account for several experimental findings. A final section deals with the relation of CRT theories to perceptual recognition theories.

475. Smith, L. E., & Whitley, J. D. Faster reaction time through facilitation of neuromuscular junctional transmission in muscles under maximal stretch. Perceptual and Motor Skills, 1964, 19, 503-509.

Fifty male students were volunteers in an experiment in which it was postulated that maximal muscular stretch would significantly increase the reaction time of an extended limb. Results substantiated the hypothesis. It was conjectured that the faster reaction time may be facilitated by the neuromuscular junctional transmission resulting from muscular stretch. Muscular stretch did not affect the movement time of the limb but had a negative influence upon the application of static strength. Relationships between "normal" (minimal stretch) and maximal stretch speeds with reaction time and static strength were found to be very low.

476. Smith, M. C. Stimulus response compability and parallel response selection. Canadian Journal of Psychology, 1967, 21, 496-503.

There has been considerable controversy in the literature as to whether human information processing of multiple inputs occurs sequentially or in parallel. It has recently been suggested that the manner in which the processing occurs may depend upon the nature of the tasks involved. This paper attempts to discover whether the S-R compatibility of each task, as determined by the relationship between RT and number of bits of stimulus (or response) information, can serve as a predictor of the nature of the processing. By examining the delay in RT_2 to two stimuli presented sequentially, as well as the composite RT to two stimuli presented simultaneously, it was found that parallel processing could occur if each of the two tasks had high S-R compatibility. It is suggested that S-R compatibility may therefore serve as a predictor of whether multiple-response selections will occur sequentially or in parallel.

477. Smith, M. C. Theories of the psychological refractory period. Psychological Bulletin, 1967, 67, 202-213.

When 2 stimuli are presented in rapid succession, reaction time to the 2nd stimulus is typically delayed. Various theories of this phenomenon, commonly referred to as the psychological refractory period, have been proposed. The theories have been placed into 3 categories: (a) central refractoriness theories, which postulate a refractoriness in the system following the 1st response selection; (b) preparatory state theories, which explain the delay in terms of the expectancy of readiness generated by the particular interstimulus intervals employed; and (c) single-channel theories, which assume a mechanism of limited capacity in the processing system. A review of the literature indicates that the latter theory best accounts for the available data. It is suggested that a limited capacity attention mechanism which is required for response selection may be the locus of the delay.

478. Smith, M. C. Reaction time to a second stimulus as a function of intensity of the first stimulus. Quarterly Journal of Experimental Psychology, 1967, 19, 125-132.

Reaction time (RT) to the second of two stimuli presented in rapid succession was examined as a function of the intensity of the first stimulus(S_1). It was found that the delay in RT_2 was greater following a dim first stimulus than following a bright first stimulus. The magnitude of this increase corresponded to the difference in RTs to the two intensity levels of S_1. These results support the prediction of a single channel model of response selection. Examination of mean first RTs revealed a general elevation in latency of RT. However, since this increase was not influenced by the inter-stimulus interval (ISI) or by the intensity of the second stimulus (S_2), and since the same increase was found on "catch trials" where no S_2 was presented, this increase is considered to be a function of change in set in the double response situation.

479. Smith, M. C. The psychological refractory period as a function of performance of a first response. Quarterly Journal of Experimental Psychology, 1967, 19, 350-352.

Proponents of a "single channel" theory of the psychological refractory period have not specified whether the single channel occupies only the decision component of the response selection, only the motor or response component, or both. In this experiment, the delay in the RT to the second of two successively presented stimuli was examined as a function of whether or not an overt motor response was made to the first stimulus, keeping the decision component constant. It was found that in both conditions RT_2 was delayed, suggesting that the decision component was a part of the single channel. However, RT_2 was delayed by a significantly greater amount if a motor response was required, indicating that the motor component is part of the single channel as well. Implications of the results for an expectancy theory of the psychological refractory period are discussed.

480. Smith, M. C. Repetition effect and short-term memory. Journal of Experimental Psychology, 1968, 77, 435-439.

2 experiments are reported which attempted to determine the basis of the "repetition effect," i. e., the observed shorter reaction time (RT) for repeated events than for nonrepeated events. The 1st experiment was designed to determine whether the effect was due primarily to peripheral response facilitation, or primarily to more central coding effects. By employing a condensing task in which the same response was made to 2 different stimuli, it was concluded that the effect was not due to peripheral response facilitation, but appeared to be more central in origin. The 2nd experiment tested the hypothesis that the repetition effect resulted from short-term activation of the S-R memory trace. Some support was found for this prediction. It was found that the repetition effect declined with increasing intertrial interval (ITI) over a range in which decline in short-term memory (STM) is typically reported, and that RT for both repeated and nonrepeated events increased with increased ITI, indicating that increased fading of the memory trace occurred in both conditions.

481. Smith, M. C. The effect of varying information on the psychological refractory period. Acta Psychologica, 1969, in press.

The two main theories of the psychological refractory period, single-channel theory and expectancy theory, make different predictions about the expected delay in RT_2 as a function of the time required to select the first response. According to a single-channel theory, delays in RT_2 should be proportional to the time required for RT_1, while an expectancy theory predicts that RT_2 is influenced only by range of ISI's employed, and should not change with changes in RT_1. By varying the number of alternatives associated with the first response, it was found that delays in a two-choice verbal RT increased with increasing number of alternatives of RT_1, supporting the prediction of the single-channel model. In a second experiment the influence of varying information of RT_2 on the latency of RT_1 was examined and it was found that latency of RT_1 increased as the number of alternatives of the second response was increased. A third experiment was therefore done to determine whether the delay in RT_1 was due merely to a change in set, or to an increase in amount of attention required to keep the second signal in store. It was found that corresponding increases were not found on trials where S was expecting the second signal but it was not presented, thus suggesting that some channel capacity is required for the maintenance of the second signal.

482. Smith, R. P., Warm, J. S., & Alluisi, E. A. Effects of temporal uncertainty on watchkeeping performance. Perception & Psychophysics, 1966, 1, 293-299.

Two experiments were conducted to assess the relative effects of signal density and regularity on watchkeeping performance. In Experiment I, three levels of density (6, 24, and 96 signals/hr.) were combined factorially with three levels of variability (coefficients of variation of 0.01, 0.10, and 1.00), and 10 Ss were assigned at random to each of the nine conditions. In experiment II, five levels of density (6, 12, 24, 48, and 96 signals/hr.) were combined with the same three livels of variability, and 13 Ss were assigned to each condition. Each S monitored a visual "blinking-lights" display for an hour under instructions to detect and report the occurrence of certain "critical signals," i. e., arrests of alternation of the lights. Response times (RT's) to correctly detected signals in both experiments decreased as a linear function of logarithmic increases in signal density. An uncertainty metric, the signal surprisal due to density, was derived, and the watchkeeper's RT was expressed as an increasing linear function of this measure of temporal uncertainty. Interpretation of these and other data support a functional, psychophysical approach to the study of watchkeeping behavior.

483. Snodgrass, J. G. Foreperiod effects in simple reaction time: Anticipation or expectancy? Journal of Experimental Psychology Monograph, 1969, 79, (Whole No. 3, Pt 2), 1-19.

An experimental method for determining the location of S's "true" simple RT distribution consists of reqarding him for responding consistently by means of narrow payoff bands, systematically varying the position of these payoff bands along the time axis, and identifying as the true RT distribution that one having minimum variability. The location of this true RT distribution was not significantly affected by increasing the foreperiod range from 0 through 300 msec. These and other results were taken as evidence for an anticipation model as opposed to an expectancy model for foreperiod effects in simple RT. The anticipation model proposes an underlying RT distribution of low variability which is unaffected by foreperiod variability and payoffs, but which combines with more variable distributions of time estimations to produce the observed RT distributions. The empirical RT distributions were highly peaked with high tails and, consistent with previous results, were better described by the double monomial (DM) distribution than by either the normal or exponential. However, the exponential was superior to the DM for distributions composed primarily of true reactions. Strong sequential effects over as many as 20 trials were observed, and were greater for no-feeback than feedback conditions.

484. Snodgrass, J. G., Luce, R. D., & Galanter, E. Some experiments on simple and choice reaction time. Journal of Experimental Psychology, 1967, 75, 1-17.

4 experiments in simple and choice reaction time (RT) are reported. Experiment I examines the effect of monetary payoffs on the accuracy and variability of time estimation. Experiment II examines the effect of moving the position of a narrow payoff band along the time axis on the variability of observed RTs. This appears to alter the proportion of bona fide reactions (of low variability) and of more variable time estimates of the foreperiod duration. Experiment III is designed to assess the factors responsible for the increased mean and variability of choice compared with simple RT distributions. It concluded that information processing rather than motor factors is primarily responsible for the difference between simple and choice RT. Experiment IV studies the relation between RT of correct and error responses as a function of variations in stimulus probability in a 2-choice RT paradigm. Finally, several theoretical distributions are eveluated by the empirical distributions obtained in Experiments II, III, and IV; none seems wholly satisfactory, but those with rounded modes and an exponential tail (e. g., the gamma) are clearly not adequate.

485. Spigel, I. M. Lift reaction time and topographic compatibility of the S-R field. Journal of General Psychology, 1965, 72, 165-172.

The current investigation was designed to explore the relationship of lift reaction time to topographic compatibility of the S-R field both within and across two-, three-, and four-choice situations. Eighty-eight Ss were employed in two experiments which required a response to a position corresponding to stimulus locations of light-on, light-off, a position of no change, and to a position of clockwise reorientation. A consistent trend emerged within each of the choice situations, though analogous differences withing the latter were not all statistically significant. R. T. to light-on was fastest, with response to light-off next. Latencies to the position of no change and to a clockwise advance were longest. The results supported the general determination that R. T. is independent of stimulus information in the case of highly compatible S-R fields. No clear linear increments emerged with the increased number of response probabilities in the case of light-on and light-off signals. Other obtained differences represented further departures from strictly linear relationships.

486. Sternberg, S. High-speed scanning in human memory. Science, 1966, 153, 652-654.

When subjects judge whether a test symbol is contained in a short memorized sequence of symbols, their mean reaction-time increases linearly with the length of the sequence. The linearity and slope of the function imply the existence of an internal serial-comparison process whose average rate is between 25 and 30 symbols per second.

487. Sternberg, S. Two operations in character recognition: Some evidence from reaction time measurements. Perception & Psychophysics, 1967, 2, 45-53.

Theories of the recognition of a visual character may be divided into three sets, defined by the way in which the stimulus is encoded before being compared to a memorized target character. A character-classification experiment was performed in which the test stimuli were characters that were either intact or degraded by a superimposed pattern. Analyses of reaction-times in the experiment lead to the rejection of two separate operations in the recognition or classification of a character. The first encodes the visual stimulus as an abstracted representation of its physical properties. The second, which may occur more than once, compares such a stimulus representation to a memory representation, producing either a match or a mismatch. A theory of high-speed exhaustive scanning in memory underlies the experiment and is given new support. The method of reaction-time analysis that is introduced, an elaboration of the Helmholtz-Donders subtraction method, may be applicable to the general problem of the invariance of perceived form under certain transformations of the stimulus.

488. Sternberg, S. Retrieval of contextual information from memory. Psychonomic Science, 1967, 8, 55-56.

When Ss name the item that follows a test item in a short recently memorized list, their mean reaction-time (RT) increases linearly with list length. The linearity and slope of the function, and the effect of the test item's serial position, imply that the tests item is located in the memorized list by an internal self-terminating scanning process whose average rate is about four items/sec.

489. Sternberg, S. The discovery of processing stages: Extensions of Donders' Method. Acta Psychologica, in press.

A new method is proposed for using reaction-time (RT) measurements to study stages of information processing. It overcomes limitations of Donders' and more recent methods, and permits the discovery of stages, assessment of their properties, and separate testing of the additivity and stochastic independence of stage durations. The main feature of the additive-factor method is the research for non-interacting effects of experimental factors on mean RT. The method is applied to several binary-classification experiments, where it leads to a four-stage model, and to an identification experiment, where it distinguishes two stages. The sets of stages inferred from both these and other data are shown to carry substantive implications. It is demonstrated that stage-durations may be additive without being stochastically independent, as result that is relevant to the formulation of mathematical models of RT.

490. Sternberg, S. Inferring the organization of cognitive events from reaction-time: Some scanning processes in active memory. In Proceedings of the Symposium, in press.

Eight experiments on the retrieval of information from human memory (four not previously published) are informally reviewed. They are discussed in the context of how inferences can be made from the structure of reaction-time data to the organization of mental processes. The reference procedure is Donders' (1868) subtraction method. A check on the validity of the method is proposed, involving the search for additive reaction-time effects; several examples of such additive effects are presented.

Use of the subtraction method has led to the discovery of two kinds of scanning process used in the retrieval of information from short memorized lists; some of the evidence is reviewed. One is a high-speed exhaustive scanning process, used in determining the presence of an item in the list; the other is a low-speed self-terminating scanning process, used in locating an item in the list. Also considered are the extent to which a test item is preprocessed before being compared to memory, the generality of the high-speed process, the effect on retrieval from a list of how well the list has been learned, retrieval from "active" versus "inactive" memory, and a comparison of the processess that underlie the recall and the recognition of contextual information.

491. Sticht, T. G. Reaction time to cutaneous onset and offset stimulation. Perceptual and Motor Skills, 1964, 19, 611-614.

Reaction times were obtained to the onset and the offset of mechanical cutaneous stimuli using two amplitudes of skin deformation. In all cases, the median onset RTs were faster than the offset RTs. These differences are attributed to differential rates of movement of the skin following the onset or offset of the stimuli.

492. Sticht, T. G. Effects of intensity and duration on the latency of response to brief light and dark stimuli. Journal of Experimental Psychology, 1969, 80, 419-422.

This study investigated the effects of duration and intensity of light flashes and momentary interuptions in a prevailing light stimulus (i. e., dark stimuli) on reaction time (RT). RTs to both light and dark stimuli decreased when the duration of low-luminance stimuli was increased. This temporal summation extended over approximately 100 msec. This suggests that the physiological mechanisms that limit the temporal summation of light and dark stimuli mav be the same.

493. Sticht, R. G., & Foulke, E. Reaction time to the onset and offset electrocutaneous stimuli as a function of rise and decay time. Perception & Psychophysics, 1966, 1, 361-365.

Reaction times were obtained to the onset and offset of 70-cps electrocutaneous signals of five rise and decay times and five intensity levels. The results show that both onset and offset RTs increase linearly with increased rise and decay times. With fast rates of rise or decay, the onset produces faster RTs than the cessation of stimulation. The opposite effect is found when long rise and decay times are used. Interpretations of these results are given in terms of neural adaptation and accommodation.

494. Sticht, T. G., & Foulke, E. Reaction time to electrocutaneous onset and offset stimulation. Psychonomic Science, 1966, 4, 213-214.

Reaction times were obtained from two Ss to the onset (beginning) and offset (cessation) of 70 cps AC electocutaneous stimuli of three sensation levels: low, medium and high. The results indicated that onset was faster than offset RTs at all three intensity levels.

495. Sticht, T. G., & Sitterley, T. E. Frequency and latency of response to offset-onset sequences of cutaneous stimulation. Psychonomic Science, 1965, 3, 425-426.

Beginning with a mechanically deforming stimulus resting on the skin, the duration of the temporal interval between the offset of the stimulus and the subsequent onset was varied from 45 to 140 msec. Response frequency and latency measurements were obtained for well trained Ss for each offset-onset sequence of stimulation. The results indicated that, (1) response frequency drops to below threshold with durations below 75 msec., and (2) RT increases as the duration is decreased. The results are discussed in terms of the recovery movement of the skin following the removal of the sitmulus.

496. Stillings, N. A., Allen, G. A., & Estes, W. Reaction time as a function of noncontingent reward magnitude. Psychonomic Science, 1968, 10, 337-338.

College student Ss were given a series of about 250 trials in a simple nonchoice, reaction time situation, some preassigned monetary reward being credited to theire accounts following each response. Each trial began, for control Ss, with a warning light, and, for experimental Ss, with a display of the reward value assigned for the trial. The reward received depended in no way upon any property of the S's response. Results revealed a small but reliable tendency for reaction time of experimental Ss to vary inversely with the magnitude of reward anticipated on any given trial.

497. Stone, G. C., & Callaway III, E. Effects of stimulus probability on reaction time in a number-naming task. Quarterly Journal of Experimental Psychology, 1964, 16, 47-55.

Subjects were required to respond to the visual presentation of numerals by uttering syllables closely resembling the names of the numerals. Information in stimulus ensembles was varied by manipulating the number of alternative stimulus configurations that could appear, the relative frequencies of stimuli within an ensemble and the probability of a response being required. An increasing linear function was a good first approximation to the relation between reaction time and information transmission. Systematic deviations from this function were found and an attempt is made to explain them by introducing an intervening variable, "effective probability."

498. Stone, M. Models for choice reaction time. Psychometrika, 1960, 25, 251-260.

In the two-choice situation, the Wald sequential probability ratio decision procedure is applied to relate the mean and variance of the decision times, for each alternative separately, to the error rates and the ratio of the frequencies of presentation of the alternatives. For situations involving more than two choices, a fixed sample decision procedure (selection of the alternative with highest likelihood) is examined, and the relation is found between the decision time (or size of sample), the error rate, and the number of alternatives.

499. Suci, G. J., Davidoff, M. D., & Surwillo, W. W. Reaction time as a function of stimulus information and age. Journal of Experimental Psychology, 1960, 60, 242-244.

Two hypotheses were tested: (a) reaction time is a linear function of stimulus information both in old and in young Ss; and (b) age differences in reaction time increase as a function of increasing amounts of stimulus information. Reaction times to a stimulus of one light-off in subsets of one light (0.00 bits of information), two lights (1.00 bit), three lights (1.58 bits) and four lights (2.00 bits) were measured. Both hypotheses were supported by the results.

500. Swanson, J. M., & Briggs, G. E. Speed versus accuracy in human information processing. Paper presented at the meeting of the Midwestern Psychological Association, Chicago, 1969.

Smith, in his excellent 1968 review, combined aspects of theories by Welford (1960) and Sternberg (1967) to identify four stages of human information processing. These stages, are, first, encoding and stimulus preprocessing, second, central processing or stimulus identification, third, response selection or decoding, and finally, response execution. The present experiment investigated the locus of the speed versus accuracy effect in terms of these four stages.

We localize the speed-accuracy effect of Hick's law as occurring during the preprocessing component of Stage 1 in Smith's paradigm of human information processing. Viewed in this way, Hick's law is not a statement of perceptual choice or identification no of response choice; rather, it is a statement of sampling choice given a level of accuracy desired by the subject. Further, Hick's law is an important component of a more general statement of additivity in choice reaction time.

501. Swensson, R. G. The elusive tradeoff: Speed versus accuracy in choice reaction tasks with continuous cost for time. Human Performance Center, University of Michigan, Technical Report No. 13, 1968.

This study attempted to discover the conditions necessary for a speed-accuracy tradeoff in choice reaction time. The subjects' entire payoff depended on both their accuracy and response time on each trial. Cost for response time was proportional to the time. Session-to-session changes in the payoff difference between a correct response and an error varied the relative attractiveness of speed and accuracy. The first three experiments used both very easy and difficult stimulus discriminations, and varied payoff over a small range in an attempt to obtain fast responses with intermediate (e. g., 25%) error rates. Tradeoffs clearly did not occur for eleven of the twelve subjects; they used only two response strategies throughout. Either subjects responded accurately, with 5% or fewer errors, or they ignored the identity of the stimulus and preprogrammed their responses, accepting chance error rates to decrease their reaction time. Experiments IV and V varied the emphasis on speed versus accuracy over a wide range, and Exp. V used a free delay interval that charged subjects only for time exceeding 250msec. After removing preprogrammed guesses, these procedures obtained clear speed-accuracy tradeoffs. All five empirical tradeoff fuctions with these difficult stimuli reached chance accuracy with response times 65-120 msec slower than each subjects' preprogrammed response time. Two different verions of the random walk model both fit these empirical tradeoff functions but neither could account for the systematic difference between times for correct responses and errors.

502. Swensson, R. G., & Edwards, W. Response stratagies in a two-choice task with a linear cost for time. Paper presented at the meeting of Midwestern Psychological Association, Chicago, May 1969.

Each trial of a two-choice task rewarded Ss for a correct response, but charged a cost proportional to their response time. All three Ss violated statistical decision models. They used only two distinct response strategies throughout the 20-24 conditions, which varied in both stimulus relative frequency and payoff asymmetry.

503. Swink, J. R. Intersensory comparisons of reaction time using an electro-pulse tactile stimulus. Human Factors, 1966, 8, 143-145.

The literature on cutaneous communication suggests that a square wave electro-pulse may be a more effective tactile stimulus for cross modality comparisons of reaction times than more traditional stimuli. It was hypothesized that the electro-pulse would give faster reaction times than either light or sound, when presented independently or in simultaneous combinations with the other stimuli. Mean reaction times of 10 male subjects, analysis of variance and mean separation test all indicated that the electro-pulse resulted in faster reacton times and less variability of responses than the other stimuli in both single and combined presentations. The hypotheses were supported and an ordering of reaction times was statistically established as following from the hypotheses. Pooling of stimuli effectiveness was offered as an explanation for the rapid reaction times of combined stimuli.

T

504. Taylor, D. H. Latency models for reaction time distributions. Psychometrika, 1965, 30, 157-164.

This paper presents an adaptation of the method of moments for comparing observed and theoretical distributions of reaction time. By using cumulants in place of moments, considerable simplification of the treatment of convoluted distributions is obtained, particularly if one of the components is normally distributed. Stochastic latency models are often poorly fitted by reaction time data. This may be because a simple latency distribution is convoluted with a normal or high-order gamma distributior The comparison method described will assist investigation of this and other interpretations of reaction time distributions.

505. Taylor, D. H. Latency components in two-choice responding. Journal of Experimental Psychology, 1966, 72, 481-487.

Donders' (1868) classical b- and c-reactions were compared with 2 similar conditions in which stimulus discrimination was reduced to the detection of perfectly detectable stimuli, so enabling the latencies associated with stimulus discrimination and response choice to be studied separately. An additive hypothesis of RT components would predict that these latency distributions should add together in the full 2-choice situation. In each of the 4 conditions, 8 Ss each gave 32 RTs. Latency distributions were described by their minima and 1st 3 moments. The data were consistent with the additive hypothesis. The component latency distributions could be fitted by a negative binomial function.

506. Taylor, M. M., Lindsay, P. H., & Forbes, S. M. Quantification of shared capacity processing in auditory and visual discrimination. Acta Psychologica, 1967, 27, 223-229.

When two or more discriminations are processed together, either they proceed in parallel with the same efficiency as when either is processed alone, or they may interfere with one another, and share the total available processing capability. Quantification of the capacity devoted to discrimination in the shared condition is possible using the additive properties of d'^2 deduced in this paper as a measure of discriminative performance. The total amount of processor capacity used for all discriminations in a shared process has been found to be approximately 85% of that used for any single discrimination performed alone. This proportion holds whether two auditory, two visual, one auditory and one visual, or two auditory and two visual discriminations are simultaneously attempted. The implication is that the discrimination processor has a finite capacity which may be deployed on wither auditory or visual tasks, and that 15% of this capacity is required to control the sharing procedure.

507. Teichner, W. H. Recent studies of simple reaction time. Psychological Bulletin, 1954, 51, 128-149.

The present status of the RT study may best be evaluated in terms of the eneralizations which it has yielded. In the opinion of the writer the following generalizations appear to have been reasonably well established.

1. There is a positive correlation between the visual and the auditory RT.

2. Simultaneous stimulation of more than one sense mododality produces faster RT's than stimulation of just one. On the other hand, successive stimulation of different senses produces slower RT's than stimulation of a single sensory channel.

3. For visual and thermal RT's the greater the extent of the stimulus in space, i. e. the greater the number of receptors stimulated, the faster the speed of reaction up to some limit.

4. Under daylight or illuminated conditions the visual RT becomes longer the greater the distance of stimulation from the fovea.

5. In the case of each receptor system, RT is a negatively accelerated decreasing function of intensity up to some maximum intensity value after which RT either becomes suddenly lengthened, the function at this point being discontinuous, or asymptotic to a physiological limit.

6. RT is a slowly falling growth function of chronological age until about 30 years after which it is a slowly rising function.

7. In general the RT of the human male is faster than that of the female.

8. The optimum foreperiod of RT may be thought of as lying in a range between approximately 1.5 and 8.0 sec. Its position in the range is determined by a large number of factors including the duration and intensity of the warning signal and of the stimulus, and the amount, locus, and time of production of muscular tension.

9. RT is not related to the length, direction, or speed of movement of the responding member.

10. Under vigilance conditions, the longer the period during which S must respond, the longer the RT.

508. Teichner, W. H. Effects of foreperiod, induced muscular tension and stimulus regualrily on simple reaction time. Journal of Experimental Psychology, 1957, 53, 277-284.

Four experiments were performed with male Ss to study the effects on RT of foreperiod length, magnitude of induced muscular tension, regularity of presentation, and intertrial interval as an attempt to resolve an apparent contradiction in results between two previous studies. In Exper. I, Ss performed under constant, regularly presented foreperiod-load combinations and with one or two intertrial intervals. Experiments II and III were split plots conducted with massed trials. In Exp. II, magnitude of tension was held constant for each subgroup, while foreperiods of different length were presented irregularly; in Exp. III the procedure was the reverse of Exp. II. In Exp. IV, both tension magnitude and foreperiod length were presented irregularly. The results appear to warrant the following conclusions:

1. Foreperiod length and magnitude of muscular tension are independent in their effects on RT.

2. RT varies inversely with magnitude of muscular tension except for combined foreperiod-tension irregularity of presentation of a high degree. In this case, magnitude of tension does not appear to affect RT.

3. Except for high degrees of foreperiod-tension irregularity or presentation, there is an optimum foreperiod of reaction. At least with massed practice for the present task, the optimum foreperiod is 5-6sec.

4. When both foreperiod and tension level are presented irregularly and their combined probability of occurrence is low, RT varies inversely with length of foreperiod.

5. All of the above conclusions may depend on the interval employed.

6. At least under the conditions of the present study, repeated elicitation has no effect on RT except under the most irregularly presented stimulus conditions, it which case RT exhibits a decrement with continued elicitation.

509. Telford, C. W. The refractory phase of voluntary and associative responses. Journal of Experimental Psychology, 1931, 14, 1-36.

510. Thomas, E. A. Reaction-time studies: The anticipation and interaction of responses. British Journal of Mathematical and Statistical Psychology, 1967, 20, 1-29.

Considers the relation between RT and the temporal uncertainty of the signal. It is suggested that the appropriate measure of signal uncertainty is the conditional probability that the signal would be presented given that it has not been presented before. This conditional probability is called the expectancy function, which it is assumed, influences the S's state of readiness and this in turn influences RT. Ways of expressing these relations mathematically are discussed. It is shown that, with a suitable representation of subjective errors in time and probability estimation, a theory can be stated which accounts for the qualitative features of a variety of experimental data. The relevance of this theory to studies concerned with central intermittency is discussed.

511. Thompson, L. W., & Botwinick, J. The role of the preparatory interval in the relationship between EEG a-blocking and reaction time. Psychophysiology, 1966, 3, 131-142.

The association between a-blocking and improved reaction times (RTs) has not been consistently demonstrated in past studies. The possible importance of the preparatory interval (PI) in this relationship has not been totally assessed, and it was felt that further exploration of this variable would help to explain the discrepancies. RTs were measured in two experiments, each using different types of stimuli and different PI durations. In the first, 4 PIs, 0.5-, 3.0-, 6.0-, and 15.0-sec, were used in a regular and irregular series. The warning signal was a 400-cps tone; the stimulus, a 1000-cps tone. In the second, PIs were 0.50-, 0.75-, 1.00-, and 1.50-sec; the stimulus was a single flash from a photo stimulator. EEGs were recorded simultaneously from the parieto-occipital region. Both peak-to-peak amplitude measures and subjective ratings of a-activity were made prior to the onset of the warning signal and the stimulus. The results did not support earlier findings of a relationship between a-blocking and RT. However, RT and a-blocking were each (independently) a function of the PI.

512. Thrane, V. C. Sensory and preparatory factors in response latency: I. The visual intensity function. Scandanavian Journal of Psychology, 1960, 1, 82-96.

Simple reaction times under irregular order of stimulus presentation are studied as a function of 3 luminous intensities viewed and covering 5 log I units at the upper half of the brightness scale. Response latency varies inversely and rectilinearly with log I within this range. Respondents tend to converge in average latency but differ more in variability as stimulus strength is reduced, the more variable Ss even at high intensity suffering relatively greater loss in speed. Both positive and negative practice effects are observed, which seem partly dependent on stimulus intensity.

513. Thrane, V. C. Sensory and preparatory factors in response latency: II. Simple reaction or compensatory interaction? Scandanavian Journal of Psychology, 1960, 1, 169-176.

The so-called simple reaction is viewed as a dynamically integrated organismic response, modifiable by sensory and preparatory factors and their interactions. The procedure used in presenting several variants of the focal stimulus regulates the specificity of the respondent's preknowledge of stimulus, and thereby the opportunity for interaction as suggested. Additional results confirm the previous finding that the differential effect of stimulus intensity is inversely related to the degree of preknowledge. The interaction is therefore considered to be of a compensatory nature.

514. Thurmond, J. B., & Alluisi, E. A. Choice time as a function of stimulus dissimilarity and discriminability. Canadian Journal of Psychology, 1963, 17, 326-337.

Disjunctive reaction time (RT) is expected to vary indirectly with the dissimilarity of stimulus alternatives: the less the difference between two stimuli, the longer the time required to choose between them (and, conversely, the greater the difference, the shorter the time). The present study was designed to measure the functional relation between RT and stimulus dissimilarity, where the latter was assumed to vary directly and linearly with the first-order differences in equal discriminability (ED) scale values of selected alternative stimuli.

Ten pairs of stimuli were selected from a previously constructed ED-scale. The stimuli were small circles of light that ranged in physical diameter from 0.0470 to 0.2383 in. Previous results had indicated that alternative stimuli in five of the pairs would confound different levels of dissimilarity with discriminability, whereas alternative stimuli in the remaining five pairs would not. Sixty different subjects were assigned at random to each of the ten stimulus conditions. Knowledge of results was provided after each key-pressing, type-b, disjunctive reaction.

Three measures of performance were used: number of errors, reciprocal RT, and the rate of information transmission, or H(t)/RT. Analyses of variance and regression analyses indicated that errors followed the expected pattern; that is, errors were a negative function of increasing dissimilarity over the range of confounded dissimilarity-discriminability values, and they were essentially unrelated to dissimilarity over the remainder of the range of values used. Disjunctive RT was not a continuous function of stimulus dissimilarity; rather, it was bifurcated into two functions, one of which was appropriate to those choice reactions involving both dissimilarity and discriminability, and the other to those involving only dissimilarity. The rate of information transmission, or H(t)/RT, was a single positive function of the logarithm of stimulus dissimilarity over the entire range of values employed.

515. Tolin, P. The influence of stimulus uncertainty in a reaction time situation. Psychonomic Science, 1966, 6, 473-474.

Forty-eight Ss participated in an experiment designed to test the effects of stimulus uncertainty on reaction time (RT). The results were interpreted as supporting the notion of increasing RT as a function of monitoring difficulty, rather than stimulus uncertainty.

516. Triggs, T. J. Capacity sharing and speeded reactions to successive signals. Human Performance Center, University of Michigan, Technical Report No. 9. 1968.

Theoretical explanations of the psychological refractory period phenomenon have focussed on the reaction time (RT) delays obtained in reaction to a second stimulus. However, it is apparent from examination of previous studies that reactions to the first stimulus are also influenced by the requirement for additional activity. The present studies were intended to define further this mutual interaction of responses to signals which are closely spaced in time. A capacity-sharing model was proposed, which emphasized the importance of preparatory processes. A two-reaction situation was used for the experiments which explored the effect of: 1) differential speed instructions between first and second reactions, 2) type of temporal structure in the sequence, and 3) variation of S-R compatibility on the first and second reactions. Two-choice reactions to visual stimuli were used generally for both first and second tasks. The results suggested that processing capacity can be allocated between the two reactions, and the preparation can develop for the second reaction prior to emitting the first response. RT to the first stimulus was found to depend on the nature of the following task. The data also suggested that a higher decrement in performance on the first reaction was accompanied by an increased rate of preparation for the second reaction. The results favored the capacity-sharing model over serial-processing models. The nature of sequential effects was also examined. Negative recency was obtained generally which contrasted with the usual positive recency of serial RT studies. However, the effect was dependent on the type of processing rules used.

V

517. Vince, M. A. The intermittency of control movements and the psychological refractory period. British Journal of Psychology, 1948, 38, 149-157.

518. Vince, M. A. Rapid response sequences and the psychological refractory period. British Journal of Psychology, 1949, 40, 23-40.

519. Vince, M. A., & Welford, A. T. Time taken to change the speed of a response. Nature, 1967, 213, 532-533.

W

520. Wargo, M. J. Human operator response speed, frequency, and flexibility: A review and analysis. Human Factors, 1967, 9, 221-238.

The innate and state-of-the-art limitations on human operator manual control speed, frequency, and flexibility are reviewed and analyzed. Advanced manual control techniques for overcoming these limitations are suggested and research relating to these suggestions is reviewed. It is concluded that a considerable increase in human operator response speed, frequency, and flexibility could accrue from use of the suggested manual control techniques.

521. Warrick, M. J. The psychological refreactory period: Disparate stimuli and responses. Dissertation Abstracts, 1961, 22, 654-655.

522. Way, T. C., & Gottsdanker, R. Psychological refractoriness with varying differences between tasks. Journal of Experimental Psychology, 1968, 78, 38-45.

2 experiments on psychological refractoriness (PR) were conducted, each with 8 different adult human Ss. PR was estimated by the increase in mean reaction time to the 2nd of 2 choice tasks when the intersignal interval was reduced from 900 to 100 msec. Thus measured, PR was greater for a 2nd task opposite in direction to the 1st than for one which was perpendicular. This held whether or not the perpendicular task required a revision of signal-response coding. Conclusions were that PR: (a) is a function of the differences between the 2 tasks, (b) is dependent on antagonism between common elements of the 2 tasks rather than on unrelatedness or absence of common elements, and (c) is capable of being analyzed into components representing signal antagonism and response antagonism. It was also found that response antagonism increased RT_1 showing that the 1st response may be affected by the 2nd signal, contrary to the storage hypothesis of PR.

523. Webb, W. B., & Agnew, H. Reaction time and serial response efficiency on arousal from sleep. Perceptual and Motor Skills, 1964, 18, 783-784.

Ss aroused from afternoon sleep show a significant decrement in discrimination reaction time task and a serial response task immediately on arousal.

524. Weiss, A. D. The locus of reaction time change with set, motivation, and age. Journal of Gerontology, 1965, 20, 60-64.

In a simple auditory reaction time experiment, using irregularly ordered preparatory intervals of 1, 2, 3, and 4 sec., time measurements of electromyographic changes were obtained in order to separate the "premotor" and "motor" components of reaction time.

After an initial series of determinations, shock-driving at the S's median RT was used in order to assess the locus of effect of motivational change.

Changes in RT because of set and motivation occurred predominantly in the premotor component and were therefore seen primarily as central rather than peripheral phenomena. However, since unpracticed Ss were used, the effects attributed to motivation might include practice effects.

The predominant difference in RT between the two age groups lay in the premotor component. Computation of comparative conduction times in the peripheral nervous system suggests that the difference is largely in the central nervous system.

Extrapolation from data in the literature suggests that the difference in effective stimulus intensity because of hearing impairment in the aged may account for only a small fraction of the age-related RT difference.

525. Welford, A. T. The "psychological refractory period" and the timing of high-speed performance--a review and a theory. British Journal of Psychology, 1952, 43, 2-19.

Experiments by several authors have shown that when two stimuli requiring hand action are presented close together, the reaction time is frequently longer to the second that it is to the first. Some previous interpretations are surveyed, and the following theory is put forward:

1. The time required by the central mechanisms to deal with the information provided by a stimulus and to initiate a response to it is, on the average, the same whether the stimulus comes closely after another or not. We may call this time the organizing time. Normally it will be the same as the reaction time for a single response.

2. The central mechanisms are liable to become engaged by stimuli fed back from the response, particularly from those parts of it where there is rapid acceleration or deceleration of movement, or where some definite sound or visual or tactile change is produced. The perception of any such feedback data will require central organizing time.

3. No two central organizing times can overlap, so that information from a stimulus arriving while information from a preceding stimulus is being dealt with has to be 'held in store' until the central mechanisms are free.

A survey of the evidence indicates that this theory, with certain assumptions about the duration of central processes, can account for the time relations observed not only in serial reaction time experiments of various kinds but in tracking and other continuous performance tasks. Special cases where apparent exceptions occur seem capable of being accounted for by reasonable additional hypotheses.

526. Welford, A. T. Evidence of a single-channel decision mechanism limiting performance in a serial reaction task. Quarterly Journal of Experimental Psychology, 1959, 11, 193-210.

An experiment is described in which the subject sat facing a display of two neon bulbs. When the left-hand bulb lit he pressed a key under his left hand, and when the right-hand bulb lit he pressed a key under his right hand. The left-hand bulb gave brief flashes at random intervals averaging about 4 sec. The right-hand bulb gave a brief flash at regular intervals of about 4 sec.

The experiment repeats (the author believes for the first time) certain essential conditions of Vince's (1948, 1950) experiments and, following detailed scrutiny of every pair of responses, is taken as evidence for the following statements:

(a) The response to a signal arriving during the reaction time to a former signal will be delayed by an amount approximately equal to the time elapsing between the arrival of the signal and the end of the reaction time to the former signal.

(b) An exception to this may occur when two signals arrive close together. In this case the two signals may be responded to as a single group.

(c) Delays can be occasioned by the monitoring of responses as well as by reactions to signals. (d) "Grouping" of signal and monitoring may occur when a signal arrives close to the beginning of the movement made in a previous signal.

A survey is made of current theories in this field and suggestions given for further research.

527. Welford, A. T. The measurement of sensory-motor performance: Survey and reappraisal of twelve years progress. Ergonomics, 1960, 3, 189-230.

In recent years the importance of perceptual and central organizing activities in sensory-motor performance has been increasingly recognised and progress has been made towards a genuinely quantitative treatment. This paper sketches the historical development of the work in this area and attempts a reappraisal under five main heads:

(a) There appears to be in the central mechanisms a 'single channel' which deals with signals or groups of signals one at a time so that signals coming in rapid succession may have to 'queue' before they are dealt with.

(b) Choice reaction times are discussed in relation to the theory that the subject gains information, in the information-theory sense of the term, at a constant rate. Conceptual models of the subject's detailed behaviour when making choices are also considered.

(c) Information theory models relating to the speed and accuracy of movement are outlined and discussed.

(d) Several formulae attempting to relate time taken to discriminate quantities of different magnitudes and the difference between them are examined.

(e) A number of wider implication of the work surveyed are outlined. Perhaps the most important of these are new approaches to 'mental' and monitoring tasks which have so far not been amenable to the normal methods of work study.

It is concluded that there is a need for joint psychological and physiological research which would be able to go beyond descriptive mathematical formulae to the study of detailed micro-behaviour and neuro-muscular mechanisms.

528. Welford, A. T. Single-channel operation in the brain. Acta Psychologica, 1967, 27, 5-22.

An outline is given of the main evidence accumulated during the last twenty years regarding the 'single-channel hypothesis'. This holds that the central decision mechanism can deal with data from only one signal, or group of signals, at a time, so that data from a signal arriving during the reaction time to a previous signal have to wait until the decision mechanism becomes free. The decision mechanism can also in certain circumstances become occupied by feedback from responding movements so that delays may occur when a signal arrives during or shortly after the response to a previous signal.

The theory is applied to the timing of countinuous performance, to paced tasks and to the measurement of 'mental load' in operation involving little overt activity. Some problems for further research are considered.

Alternatives to the single-channel hypothesis are surveyed and shown to give poorer fits than the author's own (1959) data.

529. White, C. T., & Harter, M. R. Intermittency in reaction time and perception, and evoked response correlates of image quality. Acta Psychologica, 1969, 30, 368-377.

Three studies are reviewed which are of relevance to the Donders Centenary. The first deals with periodicities found in manual reaction-time distributions. The second with certain phenomena encountered in perception wherein sequential perceived events appear to be limited by central periodic processes. The third deals with an aspect of Donders' work not covered elsewhere in this symposium: his studies concerning the refractive errors of the eye.

530. Wilkinson, R. T. Interaction of noise with knowledge of results and sleep deprivation. Journal of Experimental Psychology, 1963, 66, 332-337.

100 db. "white" noise impairs performance of 30-min. choice serial reaction; does this effect vary under (Experiment I) 32-hr. sleep deprivation (SD) and (Experiment II) increased knowledge of results (KR)? 12 enlisted men in each experiment carried out the 4 condition combinations in balanced order of presentation. The effect of noise was increased by KR, reduced by SD, and greater among Ss with previous practice on the test. Conclusions are: (a) noise impairs performance as incentive is high and as the task loses novelty through practice; (b) noise and SD produce different types of "fatigue" which may oppose each other's action; with SD arousal may be too low (especially with no KR); with noise it may be too high (especially with KR).

531. Wilkinson, R. T. Evoked response and reaction time. Acta Psychologica, 1967, 27, 235-245.

It is now possible, by the use of computer averaging techniques, to record clear evoked responses to sensory stimuli from the human scalp. This paper reviews some recent experiments which have sought to correlate the patterns of such responses with reaction time to the stimuli concerned. The conclusion is that the amlitude of certain components of the evoked response does indeed correlate with reaction time and that this correlation is probably due to the influence of attentional factors upon the behavioural and physiological measures concerned.

532. Williams, J. A. Sequential effects in disjunctive reaction time: Implications for decision models. Journal of Experimental Psychology, 1966, 71, 665-672.

Among the effects showing that decisions in serial disjunctive reaction time (DRT) tasks are dependent upon sequential structure of the signal series are latency differences between responses to repeated (sa following Sa) and changed (Sb following Sa) signals. The present study examines sequence effects and their implications for decision models. 4 DRT experiments were performed (total N = 159). In Experiment I, each of 8 groups showed a significant sequence effect in the direction of lower latencies for responses to changed than to repeated signals. Experiments II and III showed that this effect could not be attributed to either peripheral (retinal) fatigue or Ss' guessing habits. In a 4th experiment, latencies were markedly lengthened when signal sequence and response sequence were varied independently. A trial-to-trial comparison process is proposed to account for the present results, and as a useful supplement to existing decision models.

533. Wilson, K. V. Effects of size and shape differences in stimuli on disjunctive reaction time. Perceptual and Motor Skills, 1957, 7, 93-96.

Disjunctive reaction times were obtained for stimulus pairs differing in size alone, in shape alone, and in combinations of size and shape. Since one stimulus was identical in all pairs, it was possible to compare the trends in reaction times as a function of the area of the other stimulus. A rapid decreasing trend was found for five pairs differing in shape and a less rapid trend was found for the five pairs differing in size. Reaction times for the four combinations of size and shape differences were generally lower than for the differences in size or shape alone but no trend was found.

534. Windes, J. D. Reaction time for numerical coding and naming of numerals. Journal of Experimental Psychology, 1968, 78, 318-322.

Reaction times (RT) for 2 different identification tasks, numeral naming and quantity naming, have been compared in 2 experiments. Exp. I used single Arabic numerals for the numeral naming task and corresponding amounts of arbitrary figures for the quantity-naming task. Exp. II used the same Arabic numerals in different corresponding amounts for both tasks. 18 Ss served in each experiment, 9 under one task condition and 9 under the other. Exp. I showed an insignificant difference between the 2 tasks. Exp. II showed that RT was slower for naming the different quantities of numerals than for naming the numerals themselves, even when the stimuli and naming responses were identical. An interpretation in terms of identification-task conflict, as distinct form response conflic, is presented.

535. Woodworth, R. S. Experimental Psychology. New York: Henry Holt, 1938.

536. Woodworth, R. S., & Schloberg, H. Experimental Psychology. New York: Holt, Rinehart and Winston, 1964.

Y

537. Yellott, J. I. Jr. Correction for guessing in choice reaction time. Psychonomic Science, 1967, 8, 321-322.

Additional theoretical and experimental results are presented for a choice reaction time performance model described by Ollman (1966). A formula is given for estimating the latency distribution of true recognition responses from the results of a single session; the estimate is invariant with respect to changes in the proportion of "guess" responses and with respect to fluctuations in the latency distribution of guesses.

538. Yensen, R. Neuromotor latency and take-up of musculo-tendinous slack as components of RT. Perceptual and Motor Skills, 1966, 23, 747-750.

Neuromotor and movement latencies were recorded from the stretched and slack muscles of the preferred upper arm in 6 Ss. Both latencies were significantly shorter from the stretched position. Possible factors underlying this finding are discussed. The results further suggest that traditional measures of RT may be misleading when used as indices of variations in central functioning.

539. Yensen, R. Reaction time and intent to respond. Perceptual and Motor Skills, 1966, 23, 1108-1110.

It is suggested that increases in muscle tension may have occurred just prior to the initiation of the response under conditions of artificially increased mass and that these may have contributed to Whitley's (1966) finding of significantly faster RT under this condition. Following brief discussion of variation in intent to move more or less strongly, it is postrulated that the exertion of near maximum voluntary contraction of the prime movers in the initiation of a movement would decrease the RT and that such RT would correlate positively with movement time.

Z

540. Zahn, T. P., & Rosenthal, D. Simple reaction time as a function of the relative frequency of the preparatory interval. Journal of Experimental Psychology, 1966, 72, 15-19.

Simple auditory reaction time (RT) was investigated in relation to the length and relative frequency of each member of 2 pairs (1 and 3 sec. and 3 and 10 sec.) of preparatory intervals (PI) presented in an irregular sequence. For each pair, RT on trials with the shorter of the 2 PIs was a decreasing function of the relative frequency of that PI, even when the length of the PI on the preceding trial (PPI) was controlled. The detrimental effects of long PPIs were greater for the longer than for the shorter pair of PIs. The effects of relative frequency are attributed to "expectancy," and the effects of the PPI are attributed to its influence on time estimation.

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This bibliography is a compilation of 540 abstracted references dealing with reaction time in selected human information-processing tasks, through May, 1969.

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